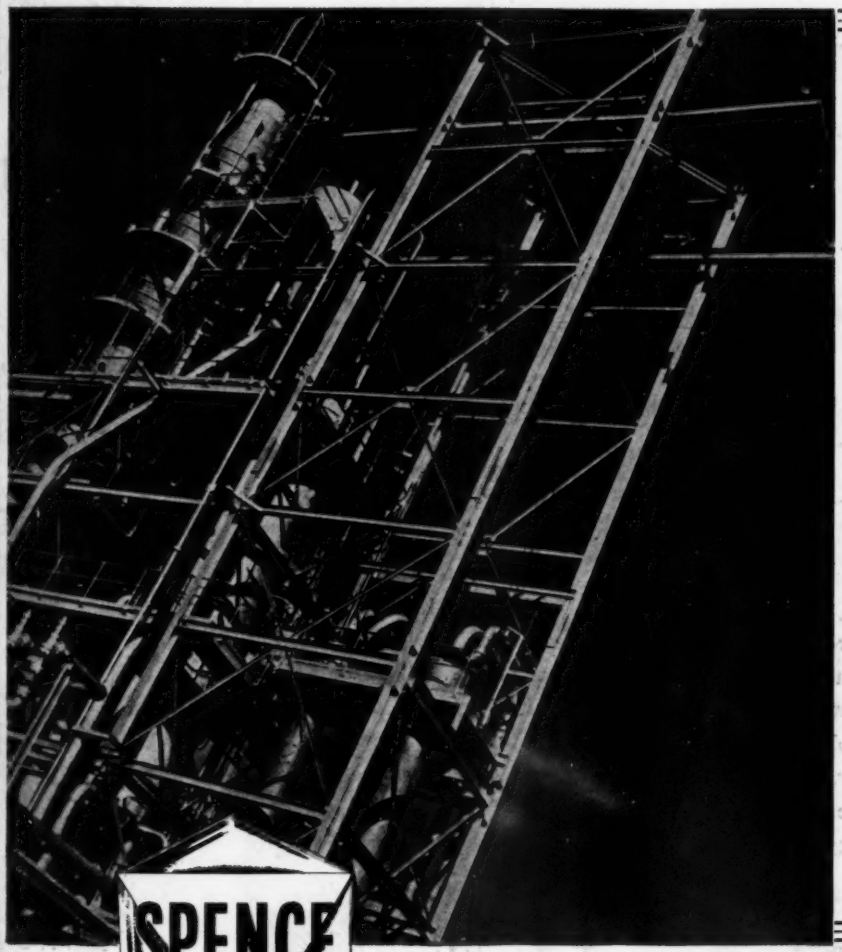
# CHEMICAL & PROCESS ENGINEERING

CHEMICAL SOCIETY
11 JAN 1957
REFERENCE ONLY.

*A monthly international review of chemical plant and operations for all industries*

VOL. 38, NO. 1, PAGES 1-50 A PUBLICATION OF THE LEONARD HILL TECHNICAL GROUP JANUARY 1957



SHELL

The first commercial hydrodesulphurising unit applying the Shell Trickle Phase technique was commissioned at the Stanlow Refinery in April 1955. The performance of this unit has exceeded expectation.

The Spence Cobalt and Molybdenum Oxides on Alumina catalyst used was developed especially for its high selectivity, stability, and mechanical strength.

*Shell Trickle Phase hydrodesulphurisation unit, Stanlow refinery. A Shell photograph.*

SPENCE

PETER SPENCE & SONS LTD · WIDNES · LANCS Also at London and Bristol

Some

# Advantages

of

## SUBMERGED COMBUSTION

- *No heat transfer surfaces*
- *Negligible radiation losses*
- *Very low consumption of fuel gas or oil*
- *Particularly suitable for corrosive liquids*
- *Small ground space required*

*Can they help you?*

Submerged Combustion enables heating to be done with absence of heat transfer surfaces and is therefore particularly suitable for the treatment of acids and other corrosive liquids. Fuel consumption is much lower by comparison with conventional heating equipment, radiation loss being negligible since heat is introduced directly into the liquid. All types of fuel gas and oil can be burned. Nordac have installed many plants for the heating, evaporating and concentrating of such liquors as spent pickle, process sulphuric acid, sodium phosphate and phosphoric acid.

The photograph shows a small plant for evaporating whale stick-water, having a heat input of 4.5 million B.T.U.'s per hour derived from the burning of heavy fuel oil. This unit was recently despatched to a whaling station in the Antarctic.

**NORDAC** CHEMICAL ENGINEERS

NORDAC LIMITED, UXBRIDGE, MIDDLESEX TELEPHONE UXBRIDGE 5131-4

# TOPICS OF THE MONTH

## *Chemical engineering in the U.S.*

THE remarkable progress of chemical engineering in the United States needs no confirmation to those who have visited that country or even those who keep contact with U.S. progress through technical journals and textbooks. The question that is asked in Europe is not what the Americans have done, but how. Does the reason for their success in this field lie in their country's great natural resources, in their dynamic approach to their problems, in their flair for organisation, or in a combination of factors?

A short answer is given by Dr. A. King, C.B.E., B.SC., head of the Intelligence Division of Britain's Department of Scientific and Industrial Research, in a preface to a new report* which throws a good deal of light on this subject. Dr. King points out that the progress of chemical engineering in the United States has been spectacular for no other reason than that the application of its principles to industry has been immensely profitable. It seems likely that hesitation in accepting the necessity for the existence of the chemical engineering profession in Europe is due to the absence of convincing proof that the employment of chemical engineers is a profitable investment. If this is so, it is so contrary to American experience that one must conclude that either chemical engineers in Europe are not being trained in the best way or are not being employed in the areas where they can make their most significant contribution.

A useful summary of American practices is provided in the report, which was prepared by Dr. P. H. Calderbank, of the Chemical Research Laboratory, on the basis of visits to educational centres and industrial establishments as well as conversations with many representatives of American chemical engineering education and practice. An important trend pointed out is a drawing away from the 'unit operations' concept, along with the squeezing out of technology from the chemical engineering curriculum to give more room for the basic sciences. These developments have led already to the establishment of 'science engineering' courses at three of the major universities in the U.S. These courses contain no technology, but concentrate on physics, chemistry and mathematics. It is hoped in this way to train graduates who will fit in to any of the established branches of engineering. Specialisation is relegated to a later stage of the educational system and the student acquires his training as a specialist either by post-graduate research and advanced study or by gaining practical experience of specialised subjects in industry itself.

*'Chemical Engineering in the U.S.A.', published by H.M.S.O. for D.S.I.R., price 2s.

The report sketches in the general pattern of U.S chemical engineering practice and shows how problems of obtaining and correlating data, process and equipment development and economic evaluation are tackled. On the subject of management, it points to the happy state of affairs brought about by the 'democratic' attitude, and comments that there is apparently no lack of excellent managerial staff in a society which consciously does nothing to promote such a species.

The criticism that has sometimes been made in Europe to the effect that the chemical engineering literature is scattered and that it is consequently unduly difficult to allocate design information is repudiated in the report. It seems that the profession, perhaps better than most, is well served by its journals, textbooks and handbooks. In facing a new design problem, familiarity with the literature and long experience are enormously advantageous. It may well be, as this report points out, that there are too few chemical engineers in countries other than the United States who have this experience.

## *Metal supplies easing?*

IN this issue one or two articles focus attention on metals as materials of construction for chemical engineering. Steel, aluminium and platinum are the subject of special authoritative articles, while in his annual review of 'Metallurgy' Mr. Holden touches on a number of other metals of growing importance to the chemical engineers.

The recent rise in the price of steel has brought into additional prominence a metal which is in any case the most vital for chemical plant construction. In Britain the shortage of steel plate is still a matter of concern to the chemical and allied industries and it is to be hoped that a change in the situation will make itself evident shortly. In a recent *Financial Times* supplement, devoted to metals, it is predicted that, along with a continuation of the rise in world demand and output, metal supplies generally may well continue to be easier than at any time since the war. From base metals to steel, from steel to uranium, the expansion of recent years is now showing tangible results. Also, there is at least reasonable hope that prices in the period immediately ahead will be more stable than they have been.

In addition, the proportion of vital metals produced outside the U.S. will continue to rise sharply, bringing increased wealth to the producing areas and increasing American interest in them. Finally, of course, the under-developed areas will increasingly participate in the consumption of metals.

### *Agitation in antibiotic fermentations —a new approach needed?*

THE most important advance made in the development of antibiotic fermentations since the inception of the deep-culture technique has been the introduction of ancillary, mechanical agitation, and today the widespread use of agitators in industrial fermentations amply testifies to their value in increasing fermentation efficiency. Nevertheless, the art of fermentation agitation has been developed almost entirely in an empirical manner because many of the questions which it raises are searching and difficult to answer and, even today, many of them remain unanswered.

This was pointed out in the December issue of our associate journal, *Manufacturing Chemist*, by T. Jackson, B.SC., who then went on to discuss the factors involved in aeration and agitation and to point out some possible new approaches. It has been suggested that, when conventional methods of agitation are used, a considerable amount of energy is wasted and that some other system, if it could be found, might prove more economical. As an interesting example of the type of alternative agitation system which might be considered, Mr. Jackson recalls the industrial alcohol fermentation. In such a fermentation, which is of course anaerobic, a ' natural ' agitation is induced by the carbon dioxide released by the fermenting yeast, and this agitation is quite astonishingly turbulent, particularly in large vessels. In such vessels it is common to find that the medium rises in the centre and descends peripherally and, as the fermentation proceeds, this circulation of the medium gains in momentum until the condition of high turbulence is reached. How far could such a ' natural ' recirculation be made use of in a large-scale antibiotic fermentation? On the whole there is probably very much more gas available for agitating the medium than in the case of the alcohol fermentation, and undoubtedly, therefore, similar or even more violent agitation and recirculation could be induced without mechanical agitators, in large-scale operations, particularly in vessels designed to encourage this ' natural ' flow pattern.

It is perhaps unlikely that gas by itself would provide all the agitation required for an antibiotic fermentation, even in an ideally designed unit, but if further agitation is still necessary it should be designed to take advantage of the gas-induced flow, if not to promote it; in this way the amount of ancillary agitation required could probably be minimised. It is possible that any mechanical agitation that is used could be employed solely to disperse air by increasing the turbulence in the rising central column of liquid, if the gas-induced motion of the medium gave a sufficiently brief recirculation time.

It is impossible, without experiment, to be sure whether or not such a scheme would enable power economies to be made, but it is a fact that mechanical agitation is a costly feature of present-day antibiotic fermentations; not allowing for the increased cooling costs, which necessarily follow the introduction of high-power agitation, the expenditure on agitation may be of the order of £50 or even £100 per fermentation. For this reason, if for no other, Mr. Jackson argues, the efficacy of the agitation systems in current use should at least be reconsidered.

### *More atomic information for industry*

A COMPREHENSIVE extension of the information on atomic energy which may be free from security restrictions has been agreed upon by the United Kingdom, the United States and Canada. Representatives of the atomic energy organisations of the three countries meet periodically to discuss the security classification of information in fields of common interest, and the declassification guide to which all three work has now been amended. As a result of this a considerable volume of material to assist the peaceful development of atomic energy will become available as reports, drawings and other materials are reviewed and declassified. British industrial organisations engaged on the nation's ambitious nuclear-power programme will find the new classes of information particularly valuable.

As an example, although many of the details concerning the Calder Hall type of reactor have been published, some aspects could be obtained only under certain security restrictions involving limitations on those engaged in the work. Acquisition of information, not only of this type but of reactors under consideration for the future, is now freed from security restrictions.

Aspects of nuclear power covered by the guide embrace ore recovery and fabrication of fuel elements and the design and operation of plants for chemical recycling of spent fuel from civilian power reactors. It will now be possible to obtain for the first time detailed production figures of uranium ores and concentrates.

The benefit of this relaxation will be felt not only by industrial firms interested in atomic energy but also by the universities and technical colleges, who will be able to provide fuller and more up-to-date information.

### *Valve control by temperature difference*

A CONTROL device which permits the mixture of two liquids only when they are at nearly the same temperature was developed in the United States recently. A system was constructed for an application where the two temperatures in question ranged from 50 to 650°F. and where the difference to be detected was adjustable from 25 to 75°F. The system trips a relay whenever the prescribed temperature difference is reached, regardless of the actual value of the two temperatures in their range.

The valves controlling the flow of the two liquids are actuated by a magnetic amplifier system, described in the November 1956 issue of *Control Engineering* by W. M. Kendziorek, of Westinghouse Electric Corp. The system measures the resistances of two resistance thermometers, converts them to meter indications in degrees Fahrenheit, measures the difference between the two temperatures, and finally causes a relay to be energised when the difference exceeds a given magnitude.

### New zirconium recovery process sought

A METAL that, because of its corrosion resistance and physical properties, will come into its own for chemical engineering and other uses when a more economical method of producing it has been devised is zirconium, prominent now as a material of construction for nuclear reactors. Plans to develop a method of recovering zirconium from impure sponge metal, mill scrap and zirconium alloys, announced by the U.S. Department of the Interior, are therefore of especial interest. A $110,000 research project, financed by the U.S. Atomic Energy Commission, is being undertaken by the Bureau of Mines at its experimental station in Boulder City, Nevada. Hopes are pinned on electro-refining methods, based on experience gained in the electro-refining of titanium.

### Fuel cells—no commercial development yet

ONE of the most fascinating, and at the same time tantalising, tasks in which chemical engineers have been engaged is that of developing fuel cells in which electrical energy is obtained by the direct conversion of the free energy of combustion. A survey of the progress made in this field, with some discussion of possible future trends, was given by A. M. Adams in CHEMICAL & PROCESS ENGINEERING, 1954, **35** (7), 199-203, and (8), 238-240. More recently, in the Birmingham University *Chemical Engineer*, R. B. W. Price has summed up work in this field and points out that, superficially, the most attractive type of cell is one employing the heat of combustion of carbon, in the form of coal, with air, using an aqueous electrolyte. Unfortunately, carbon and oxygen are not electrochemically active and do not ionise readily even at high temperatures and pressures. As a result, numerous other electrode/electrolyte systems have been tried.

The most important practical consideration today is that of current density, since this will determine the size of cell unit required for a certain output. Over 150 cells have been suggested and, although many possess excellent overall efficiencies, they are uneconomical for commercial use owing to size considerations. A comparison of fuel cells proposed in recent years shows clearly, according to Mr. Price, that the Bacon cell is in the most advanced stage of development of any cell now being investigated. It is, however, unlikely to prove suitable for bulk power generation unless the problems of producing cheap hydrogen from coal, either by purifying it or operating the cell on impure gas, can be solved. A more likely application would be for energy storage in conjunction with local wind-power or water-power generators by operating the cell in conjunction with electrolysers.

The problem of large-scale power generation still remains. No cell has yet been operated on bituminous coal, even in the laboratory. Incomplete oxidisation, accumulation of ash and high temperatures have proved insurmountable difficulties. Coke has not proved much more successful since it is less reactive and the ash problem is aggravated. Gases have been used with some success, particularly in the high-temperature Davytan cell, but here again is the important problem of the cost of fuel. At the moment, Mr. Price says, the added cost of gaseous fuel would more than compensate for advantages over the heat cycle due to increased efficiency.

The possibility of combining underground gasification of coal with the fuel cell has obvious attractions. The presence of natural diluents in the fuel gas would probably only depress the voltage slightly in high-temperature cells, but the complications of heat exchange arrangements might prove formidable.

### Push-button mathematics

ELECTRONIC computers that can analyse experimental data and solve complex mathematical problems at split-second speed are proving increasingly useful for solving design problems. Some concerns that might otherwise be interested have been put off by the initial cost, but where they have been installed computers have quickly paid dividends. Thus the Aviation Division laboratories of Olin Mathieson Chemical Corporation, U.S., have recently installed a computer, of the magnetic drum digital type, which will cut down the time needed for scientific research studies from years to weeks. At the same time it will save skilled scientists and engineers from long hours of calculating, releasing them for more important work. The computer will be used to calculate chemical equilibrium constants, reaction temperatures, and enthalpy and entropy of chemical compounds which are of potential interest in the field of high-energy fuels.

The company is presently studying the oxidation reactions of over 200 such compounds, and this number will constantly be added to in the future. Using the long-hand method of calculation, a research worker requires about three weeks to evaluate one chemical compound. Equivalent work on the computer, once the initial programming is completed, can be accomplished in 10 to 12 minutes.

The machine will also be used by Olin Mathieson for theoretical evaluations of various chemical combinations and for equipment design work and statistical analyses.

### CHEMICAL PLANT COST INDEX

*With this issue we introduce something new for chemical engineers—an up-to-date cost index based on British conditions and prices. This month, data are given comparing past and present costs; in future issues new figures will keep readers informed of changes.* *See page 29.*

### *Natural gas in steel-making*

THE shortage of oil heightens interest, in Britain, in the possibilities of using natural gas as an industrial as well as a domestic fuel and the Gas Council's latest experiments, reported on another page, will be watched with keen interest.

In Italy, the problem is not so much finding natural gas as finding ways of making more use of it and, in the steel industry, experiments have been made at Omegna, in northern Italy, with the object of using natural gas as fuel for a Siemens Martin furnace of 50 tons capacity. When the gas was used in its natural state, the results were unsatisfactory, but when the proportion of higher hydrocarbons was increased by carburetting the gas with fuel oil, the experiments were crowned with success. Best results were obtained by mixtures in which fuel oil contributed 20 to 25% of the calorific value, and such mixtures were made by using 1 l. of fuel oil for 4 to 5 cu. m. of gas.

These activities were reported by B. Matuschka and G. Morini in *Stahl & Eisen*, 1956, **76,** 1167, and they point out that, compared with producer-gas heating, the carburetted natural gas offered three advantages: a better yield, an improved steel quality and a considerably greater longevity of the furnace.

### *Synthetic fibre filters*

AN article in our December issue dealt with mineral wool; a substance which has some points in common with mineral wool is ' glass wool,' composed of glass fibres. The uses of this glass wool also include heat insulation and filtration and such uses are being widely extended. That glass wool should be employed in this way is easily understandable, since it is comparatively easy and cheap to manufacture and also because glass is a very inert material highly resistant to attack by micro-organisms and chemicals.

It is, therefore, interesting to note that investigations have recently been carried out to ascertain how far it is possible to manufacture comparable synthetic fibres and how efficient these may be, in the form of webs or mats, with the fibres arranged at random or otherwise suitably aligned relative to each other, for filtering smokes or aerosols, which normally are most difficult to filter.

These investigations have been carried out in an American Naval research laboratory (Washington) and the results are described in an article by Mr. A. J. Hall, B.SC., F.R.I.C., F.T.I., F.S.D.C., in our associate journal *Fibres* for November. He points out that their chemical nature and surface characteristics are important factors in the consideration of fine fibres as filters.

In these recent investigations, the method of forming the fine synthetic fibres from such fibre-forming polymers as polyamides, polyesters, polyethylene, polystyrene and polymethyl methacrylate was based, to a large extent, on that already in use for the production of glass fibres. It was found that fibres produced by this method were not, as might be suspected, irregular, particularly with regard to thickness. Nylon is very suitable for fibre formation by this method, and in the spinning of nylon fibres they were found to vary within the reasonably close limits of 0.11 to 0.22 microns. Not all the polymers investigated, however, proved suitable for conversion into fibres.

Examination of the webs of synthetic fibres produced has shown that they have excellent filtering properties which can be controlled first by the fineness of the fibres and second by mechanical pressing of the resulting fibre webs to increase their density. These investigations, indeed, might well stimulate other ideas for using synthetic fibres not only for this particular purpose, but also for others which have not yet been envisaged.

### *Iron ore reduction with hydrogen*

A CHEAPER process for the reduction of iron ore, using hydrogen instead of coke, may come from experiments being carried out by United States' scientists. In a laboratory method evolved by Hydrocarbon Research Inc. in collaboration with the Bethlehem Steel Co., continuous fluidisation at about 900°F. and 400 p.s.i. is involved. The hydrogen is produced by the *Texaco* HRI partial oxidation process and is expected to cost less per unit of metallic iron than the coke used in blast furnaces of the conventional sort.

An important point about this process is that, although the iron still contains impurities from the ore, impurities such as sulphur and carbon (which are introduced when coke is used) do not occur.

Laboratory tests having proved satisfactory, engineering studies for a full-scale plant are being made.

### *New glycerine campaign*

THE new campaign for bringing the uses of glycerine and its derivatives to the attention of industry, mentioned in our November issue, seems now to be firmly settled in, indicating the present abundance of this chemical after a long period of short supply. It will be recalled that, between the two world wars, glycerine was frequently in oversupply and, at intervals, had to be run to waste, but during the second world war the need for explosives changed this situation. After the war, glycerine continued in short supply because two new industries —transparent paper and paint resins—which are large consumers of glycerine but only operated on a small scale before the war, rapidly expanded. At the same time, however, the supply of natural glycerine failed to rise at the same rate as the general increase in industrial output, because of the increasing use of soapless detergents which do not produce glycerine as a by-product during manufacture.

The shortage of glycerine and the high price it realised—especially in America—led to the development of plants for the manufacture of synthetic glycerine. Since then, the glycerine market has been in and out of balance, but with additions to the synthetic glycerine plants the industry is in a position to meet all foreseen requirements and, because of this, was able to discontinue the British allocation system several months ago.

# STAINLESS STEEL
## from the User's Point of View

**By H. J. Wilson, M.I.Mech.E.**
(*Monsanto Chemicals Ltd.*)

*Stainless steel has proved invaluable as a material of construction for the chemical engineer, but, with new developments, new problems of design and construction are constantly being created. Mr. Wilson discusses some of these and also shows how co-operation between users and suppliers of stainless-steel castings and equipment can overcome present difficulties.*

TODAY an article on stainless steel is almost out of date before it is printed as the development of various alloys continues to increase very rapidly, each alloy having a slight characteristic difference which lends itself to a different application. However rapidly these alloys are developed, the chemical industry always appears to be one jump ahead with a chemical for which there is no suitable material capable of being fabricated into chemical plant.

Fortunately new developments in other materials such as polyvinyl chloride and polyethylene and titanium are, on the other hand, becoming available to fill the gaps left by stainless steel. In the case of plastic materials, these are only suitable for low temperatures and are still quite costly, whilst titanium, as yet, can only be used where cost is of little importance. It is difficult to foresee the plastic materials being used in any but limited applications and the same applies to titanium unless its price can be very drastically reduced and the techniques of welding considerably simplified.

### Types of stainless steels

Stainless steels in common use are of three principal types: austenitic, martensitic and ferritic.

Austenitic stainless steels contain both chrome and nickel; the total content of these elements is at least 23%, the minimum content of chrome being 16% and of nickel 7%. The most common in use is 18% chrome, 8% nickel. Austenitic stainless steels work-harden readily, they are very shock-resistant and are somewhat difficult to machine unless they contain sulphur or selenium. They can be readily hot worked and can be cold worked when allowance is made for their rapid work hardening. Welding can be carried out without difficulty and, if the welding operation is properly controlled, the resistance to corrosion is not impaired.

These steels have the best high-temperature strength and resistance to scaling. The corrosion resistance of austenitic stainless steels is usually better than that of the martensitic and ferritic stainless steels.

Various grades of stainless steel can now be obtained for use in temperatures in excess of 2,000°F. (1,090°C.), although at these elevated temperatures the material has a relatively short working life. These materials can be had as straight chrome steel, 18/8 chromium nickel columbium, 24 chrome 12 nickel and 25 chrome 20 nickel.

There are no less than a dozen types of stainless steel which will operate up to 1,500°F. (815°C.). In general the plain chromium steels are more sensitive and during heating to high temperatures are subject to grain growth; thus the plain chrome steel has a more limited field than the chrome nickel austenitic steel. Furthermore, under stresses at elevated temperatures their ability for load holding is less.

Martensitic stainless steels can be hardened by heat treatment and are primarily straight chrome steels. They can be cold worked without difficulty when the carbon content is low. They can be machined satisfactorily and are very tough.

Ferritic stainless steels are very low carbon chromium steels. They are not hardenable by heat treatment. They can be hot or cold worked.

In all these steels the carbon content varies between about 0.08 to 0.2%, although contents up to 0.9% can be used in martensitic steels. Additional elements are silicon, tungsten, molybdenum, niobium and titanium. These elements are added singly and sometimes in pairs in small quantities. They assist in weldability, resistance to weld decay, resistance to cracking in high-temperature steels and increase the strength at high temperatures.

In the early design stages the chemical or mechanical engineer is faced with the problem of deciding whether mild steel, or the more expensive stainless steel, is more suitable for a particular application. This decision is not always easy to make, especially if there is some doubt as to whether stainless steel should be used in place of mild steel.

The price differential between mild steel and stainless steel is still a considerable factor. Even taking into account the higher design stresses which one may use for stainless-steel vessels, stainless steel equipment is still approximately four times the cost of mild steel.

### Stainless clad steels

Plates and sheets of mild steel clad with stainless steel have been produced commercially for about 10 years. The layer of stainless steel usually constitutes between 10% and 20% and either one or both sides may be coated. Such clad steels have been developed largely to reduce the cost of stainless plates particularly for the many applications where only one side of the plate needs to be stainless.

Although the clad plate itself is cheaper in the first instance, it is expensive to fabricate as any exposed edges have to be protected.

One of the disadvantages of stainless steel is its very low thermal conductivity; consequently a jacketed stain-

less vessel or a stainless heater is subject to produce local hot spots, whereas clad material reacts more in line with straight mild steel. Vessels designed using this material are a lot thicker than they need be as the design stresses are taken on the mild-steel component only.

### Choice of material

In cases where mild steel is not completely resistant to corrosion where stainless steel would be the ideal alternative, it is sometimes found prudent to tolerate the corrosion in the mild steel which has a very much cheaper replacement cost. Consideration, of course, has to be taken on the type of plant, the cost of loss of production during shutdown for replacement and the possibility of a failure during operation which might cause a more serious breakdown. Therefore, this type of decision is usually left to a batchwise process where frequent examinations and replacement can be made between batches.

In addition to the question of price, there are various other factors which will influence the designer's decision as to whether stainless steel should be used in place of mild steel or any other material. These factors have a great influence on the plant design and can be enumerated as a pressure factor, a temperature factor and a factor covering the properties of the product. All three will vary in any plant.

**Table 1. Stainless Steel *versus* Some Common Chemicals**

| | |
|---|---|
| Acetic acid .. | Various grades of stainless steel cover all percentages up to 400°F. |
| Alum .. | Up to 10% solution, up to boiling point. |
| Ammonia .. | All concentrations and temperatures. |
| Ammonium sulphate | Saturated solutions up to boiling point. |
| Benzole .. | Under all conditions. |
| Calcium hypochlorite .. | 2% solution up to 70°F. |
| Carbon tetrachloride, pure .. | Up to 70°F. |
| Chlorine gas, dry .. | Up to 70°F. |
| Chromic acid | 5% solution, up to 70°F. |
| Fatty acids .. | All temperatures and conditions. |
| Hydrocarbons: | |
| Aliphatic .. | ditto |
| Aromatic .. | ditto |
| Nitric acid .. | All percentages at room temperature, 65% to boiling point. |
| Oxalic acid .. | 5% to boiling point. |
| Phenol .. | Up to boiling point. |
| Phosphoric acid | Up to 45% and boiling point. |
| Sodium hydroxide | 20% solution, up to 70°F. |
| Sulphuric acid | Diluted, up to 70°F. |

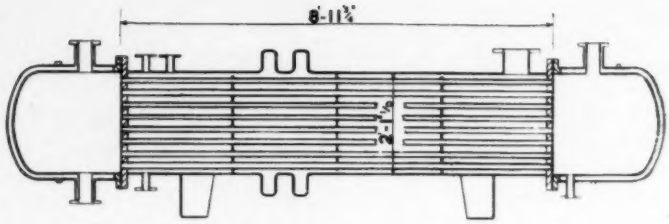



**Fig. 1. Stainless-steel heat-exchanger, referred to in text.**

The pressure factor will influence the method of design, the thickness of material and methods of fabrication. There is always a risk that fatigue may increase if the pressure range is excessive and cyclic. Alternative materials or techniques may have to be used and under some circumstances heat treatment may be necessary.

The temperature factor will influence the designer in deciding on the best materials for the conditions in question. The properties of the product factor, however, must have the final say.

The many valuable characteristics of stainless steel will appeal to the designer seeking a suitable material to handle the properties of the product under different conditions. These conditions may call for:

(*a*) Corrosion resistance.
(*b*) Contamination resistance, preventing:
  (i) discoloration;
  (ii) contamination in batch processes (where some of the previous batch has remained in the vessel).
(*c*) Abrasion resistance.
(*d*) Internal finish — polishing is called for where a material tends to build up on vessel walls.
(*e*) External cleanliness in the case of pharmaceutical plants.

### Corrosion resistance

The resistance of stainless steel to a variety of common chemicals is given in Table 1. Although there is a vast amount of information available on the chemical resistance of stainless steel to various chemicals under various conditions, it is not absolutely safe to rely upon either the literature or laboratory tests. The latter often are deduced only under ideal conditions. The only safe way to ensure that the right material has been chosen is for the tests to be carried out under field conditions. Then the temperatures, the pressures and the properties of the material are identical to those that would be found in actual practice. This type of field test is not always possible, but should be simulated on a pilot plant rather than in a laboratory.

### Discoloration

Ferrous discoloration is a most common occurrence in mild-steel equipment, but is invariably overcome by replacing mild steel with a suitable stainless steel. Where a product has a strict colour specification, stainless steel is usually satisfactory as long as there is not too much nickel present. Under certain conditions, nickel causes a green discoloration (nickel chloride).

In cases of this kind it is quite often possible to fabricate much of the plant in material less expensive than stainless steel. Stainless steel is then introduced at the point where the intermediates are either mixed or reacted to form a final product in which discoloration is undesirable.

Examples of this can be seen in the case of a distillation column in mild steel with the vapour pipe in stainless steel and a stainless-steel heat exchanger. In this case the discoloured product remains in the column, and no contamination will be experienced when the vapours reach the vapour pipe and heat exchangers.

With pharmaceuticals, many of which are produced batchwise, and food, contamination is of a different nature, and in these cases it is usually essential for a vessel to be highly polished on the inside so that on the completion of a batch the whole of the inside of the vessel may be thoroughly cleaned down and all vestiges of the previous batch removed. Under these circumstances the designer is faced with the problem of designing a vessel which has no crevices or corners in which material could lodge and be difficult to remove.

Agitators, stirrers, etc., branches, thermometer pockets, all have to be 'streamlined' so that cleaning can be facilitated without recourse to special tools and equipment. In addition to the manufacture of pharmaceuticals and food, this contamination is often

experienced in the chemical industry, where a catalytic reaction takes place batchwise. In such a case any material left in from the previous batch may prematurely start the reaction on the next batch.

Thus all equipment has to be polished and thoroughly cleaned between batches. Polishing is very expensive, but the alternative would be even more expensive, probably resulting in a lost batch or even an explosion.

### Abrasion

In certain grades stainless steel, being a fairly hard material, resists erosion and/or abrasion very well and renewable check plates, fabricated in stainless steel, are used for centrifugal pumps when employed on an abrasive product.

### Cleanliness

The need for internal cleanliness as far as pharmaceuticals and food is concerned is obvious; a polished interior is, therefore, always necessary. There are occasions, however, where certain chemicals will film on the inside of a vessel, which in turn cuts down the rate of heat exchange where the outside of the vessel is jacketed. Naturally for controlled conditions this film is undesirable and, under these circumstances, the inside of the vessel is invariably highly polished. This does not entirely eliminate filming, but it reduces it very considerably.

External cleanliness is frequently essential for pharmaceuticals and food. Under these circumstances the vessel is designed to have a clean external finish to match the internal features of the building in which it is installed. This calls for intelligent design and general ' streamlining.'

In the case of agitated vessels, one of the biggest problems is to prevent any of the grease from the agitator gland from entering the vessel—this is now much simplified since the mechanical seal or packless gland has been further developed so that it is both reliable and effective.

### Designing in stainless steel

The designer of stainless-steel equipment must carefully watch many points. He has the advantage over mild steel of superior working and proof stresses. He can reduce the size of scantlings, which helps to reduce the price differential between mild and stainless steel.

Some grades of stainless steel are almost as easy to fabricate as mild steel. On the other hand, certain grades have to be carefully fabricated and heat treated after welding. It is essential to match the welding electrodes with the material, otherwise weld decay may be promoted or the resistance to corrosion reduced.

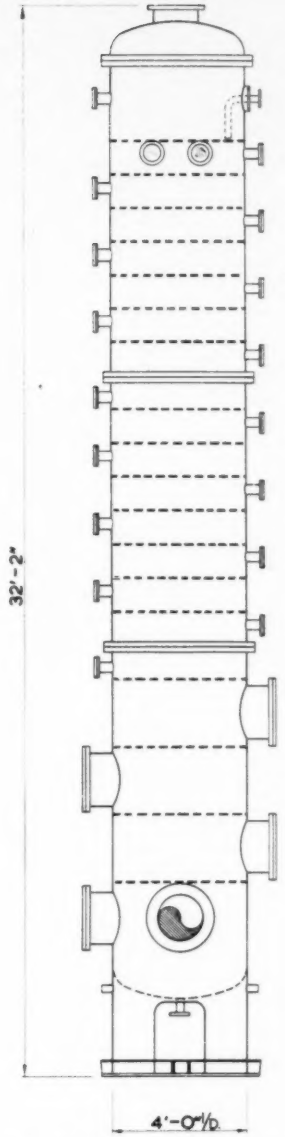



**Fig. 2 Bubble-cap column in stainless-steel, with removable plates.**

For many years now Monsanto Chemicals Ltd. have been using stainless-steel equipment at their factories under very varied conditions for the manufacture of many different fine and heavy chemicals to very high degrees of purity. The applications have been in bodies of pumps and valves, impellers of pumps, valve trim, heat exchangers, ducts, fans and blowers, piping, storage tanks, distillation columns (packed and bubble-cap type), reactors, agitated vessels, autoclaves, etc. This equipment is generally in the medium- to low-temperature and low-pressure class, though there are in fact extremes of 850°C. and 2,000 atm. Examples are shown in the accompanying diagrams.

Heat exchangers fabricated in stainless steel provide a problem of their own, especially where the tubes are expanded into the tube plate rather than welded in. Owing to the work-hardening characteristics of the material, the amount of expansion permissible is very limited. This calls for tubes requiring very close tolerances. To obtain such tolerances is usually expensive and two alternatives may be adopted—one is to have the ends of the tube enlarged and sized, the other is to obtain a matched set of tubes with the tube plate holes drilled to suit.

### Some examples of stainless steel construction

The stainless-steel heat exchanger sketched in Fig. 1 is of a multi-pass type, operating at fairly high temperatures, and an expansion piece is, therefore, necessary. The product being handled solidifies at about 120°C. and necessitates the use of steam-jacketed heads; it will follow, therefore, that all process pipes to and from the heat exchanger will also have to be steam jacketed—steam pressures 150 p.s.i. This particular heat exchanger is a horizontal one and in this case the collection of product in the expansion pieces is not harmful. It must, of course, be emptied of product when the equipment is removed for maintenance purposes. This is a case where a floating-head type of heat exchanger would have been preferable, but for certain process limitations this was not practical. The whole heat exchanger, including the ends, was fabricated from plate.

Stainless-steel hoppers are usually fabricated in very thin sheet. This is possible as there is no corrosion problem, although, in some instances, when dealing with hard plastic material, there may be an erosion problem. If a hopper or silo is to be very large, then it is usually stiffened externally with mild-steel angles, tees, etc., and quite often in the case of spray driers the roof of the drying chamber is actually suspended from the steel framing or cage. Many types of ducting, fans, hoods and cyclones used in the manufacture of plastics are

fabricated in stainless steel. Stainless steel is usually chosen here as ferrous contamination may cause trouble and, of course, it is necessary to ensure resistance to abrasion.

The small, stainless-steel column shown in Fig. 2 is of the bubble-cap type. It has removable plates which can be dismantled and removed through the manhole. As it is fabricated in stainless steel the plates, bubble caps, etc., are extremely light and, therefore, are quite easily handled through the manhole. The need for separately bolted-up sections is somewhat obscure. However, as the distillation is not of the vacuum type, these joints are not considered an embarrassment, but rather an advantage, as this particular piece of equipment is located in a very cramped quarter of a building and removal can easily be achieved.

There are many ways of doing a job, all of which appear to be correct and many of which are influenced by the conditions prevailing at the time of design. The stainless-steel conversion pot shown in Fig. 3 was an interesting development on a process that had been running for some years. Originally the body of this vessel was fabricated from stainless plate, having a dished and flanged end, longitudinal and circumferential welds. The top body flange was welded and the removable cover was in cast steel. The internal dip pipe was fabricated in stainless-steel plate and welded to the cast-steel cover which, incidentally, was originally flat rather than dished as shown on the drawing.

The operating conditions were 100 p.s.i.g., at 850°C., with direct firing on the outside of the body and on the dished end. Considerable difficulty was experienced in maintaining a tight joint and the time came when this vessel just had to be redesigned.

The quality of stainless steel called for was unobtainable in plate form in Britain; with the generous co-operation of the steel makers, however, we were offered a spun cast body in the correct quality of stainless steel with spun cast dip tube, baffles and cover. Needless to say, this was more expensive than the fabricated type of pot, but held possibilities which were worth consideration.

In conjunction with a firm of fabricators a complete redesign, necessitated by the changeover from gas firing to oil firing, was carried out. The castings were made and the vessel fabricated. All this was achieved by excellent co-operation all round.

In all, three such conversion pots

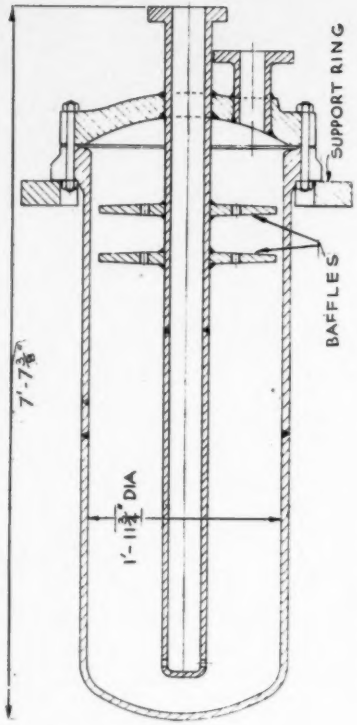



**Fig 3. Conversion pot.**

were required. All were located in one combined furnace, but each had its own separate chamber, with three burners around the periphery. Thus, with a much harder flame, furnace design needed careful consideration and a great deal of attention was given to ensure balanced forced draught, even heating and complete combustion.

Direct flame impingement from the three oil burners would naturally have been undesirable and the burners were directed into the furnace at a tangent so that generally heat was applied by radiation. As with most new developments we had our problems and difficulties which were finally overcome, and the pots were installed and finally put into operation.

The plant has now run many hundreds of hours and given no trouble at all. On final analysis, fabricated vessels compared very favourably with the spun cast vessel. This was a case where the temperature was the limiting factor, plus the corrosion from the burners and erosion inside the vessel.

## Jacketed vessels with agitation

With many processes stainless-steel, agitated, jacketed vessels are used. The main variations which affect design are in the working pressure of the steam in the jacket type of agitator and the internal finish of the vessel. Wherever possible the agitator drive is through a reduction gear box having a lighthouse-type housing on top, in which is located a thrust bearing taking both the static and dynamic loads of the agitator. Thus the bearing located in the gland housing has only to withstand side thrust from the shaft and to act as a steady. The use of footstep bearings is deprecated for chemical work. Normally the gland housing is a combination of a straightforward packed gland and a mechanical seal at the lower end.

Where the working pressures in the jacket are high, staying has to be carried out. In the case of an exothermic reaction, which requires a considerable amount of heat to get it going, the process is quite often started by the application of steam to the jacket which, when the reaction has commenced, is immediately switched over to water cooling so that control may be maintained. In cases like this directional flow is usually necessary to enable the water flow to be maintained at a fairly high velocity. This directional flow is usually achieved with the aid of the spiral baffle welded to the outside of the body of the vessel. A jacket is slipped over the top, the clearance being as fine as is practicable. Jackets are usually fabricated in mild steel unless, of course, the jacket is being used as a heat exchanger, when, in some cases, it would be of the same material as the body.

## An experience with stainless-clad plate

Some years ago, when stainless steel was in very short supply, we fabricated an agitated, jacketed vessel (Fig. 4) in stainless-clad material, *Colclad*. Every part of the vessel, except the smaller branch pipes and jacket, was fabricated in stainless-clad plate. The shaft was of solid stainless steel, although at one time, when it appeared impossible to obtain, a heavy mild-steel shaft covered in stainless steel was contemplated.

The use of clad plate involved a great deal of detail drawing work to ensure that the exposed end of every plate was suitably covered with thin stainless-steel sheet welded into position. The gland housing on the inside of the vessel was fabricated by rolling a piece of clad plate into a cylinder with the cladding on the inside, the outside being covered by a thin stainless-steel sheet plug welded into place. The exposed end was covered by a piece of thin stainless-steel sheet.

Each of the pads—*i.e.* bottom outlet

and agitator support pad—was treated in the same way. The removable agitator arms were fabricated from two clad plates, placed back to back, welded together, and plug welded in parts with a sealing strip of stainless steel around the edges. The agitator plates were then welded to a cast stainless-steel support which was clamped to the shaft. To complicate matters the inside of the vessel had to be ground to a smooth finish — not polished—which meant that the manufacturer had to exercise extreme care, both in the fabrication and grinding, to prevent the exposure of any mild steel. The joint for the manhole was a retained type—accordingly this part of the opening was fabricated from solid stainless steel. That this vessel was put into service and has been in continuous operation since shows that complicated fabrication can be carried out with this material, but the increased cost of fabrication makes free use of clad plate less attractive. A reduction in price of the clad plate would encourage the chemical industry to use more of this material. It must be added that for straightforward vessels stainless-clad plate is ideal.

### Lining mild steel with stainless

As an expedient just after the war, a small vessel was made in mild steel and lined with very thin stainless-steel sheet (16 gauge). Although in this particular instance the vessel was successfully made and put into use, this type of construction leaves a lot to be desired and should only be resorted to in the event of acute shortage of material or where speed is of the utmost importance. The difficulties to be encountered are those of welding the thin sheets; possibility of a porous weld with subsequent leak and corrosion or contamination; pressure build up between the shell and the stainless-steel sheet; complicated details making manufacture difficult.

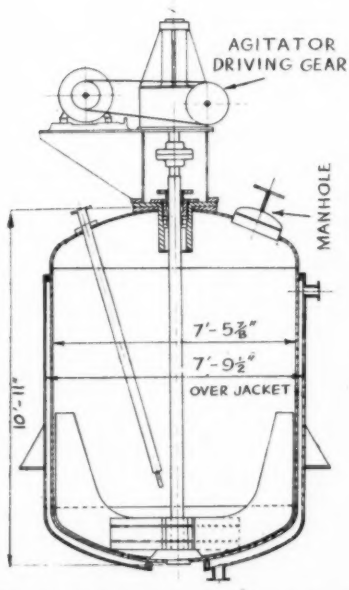



**Fig. 4. Agitated, jacketed vessel in 'Colclad.'**

As purchasers of a considerable amount of stainless-steel equipment we are finding that manufacturers, although capable of making a sound job in stainless steel, unless very carefully inspected during fabrication, tend to neglect some of the fundamentals and allow a lowering of standards—permitting the workmen to adopt bad practices such as welding on flanges after machining, using wider tolerances. Under these circumstances the manufacturer is not accepting his responsibilities. Unfortunately this sort of thing does not apply only to the fabrication of stainless steel, but appears to fall in line with the general practice of accepting lower standards, which cannot be permitted in the chemical industry.

### Piping

Stainless-steel piping also brings its own problems. The pipe normally used is solid stainless steel, although stainless-lined and stainless-clad pipe is available in solid-drawn forms. So far, however, the price differential is not sufficiently great to make it worth our while investigating using a lined pipe as an alternative. Stainless-steel piping is usually very much thinner than mild steel. Welding and fabrication generally have to be carefully controlled. Bends when being pulled will more readily flatten, and welding of very thin pipes can be difficult.

The joining of two pipes so that a length may be removable has been done in many different ways. For the smaller-bore piping it is possible to use a stainless-steel compression fitting which is very effective up to 3,000 p.s.i., but as the majority of piping is between 2- and 6-in. bore most of it is flanged. Flanging may be carried out in one of many ways:

(1) A heavy stainless-steel flange may be welded to the pipe—rather costly from a material point of view, but, nevertheless, it makes a good joint.

(2) Mild-steel backing flanges are used after either:

(*a*) welding a thin, flat annulus on to the end of the pipe, or

(*b*) punching the centre out of a disc so that a small branch is formed on the disc. This branch is then butt-welded to the end of the pipe.

In each case the bolts and joint are held by the backing flanges only. Method (*b*) is the better.

(3) A small ring of solid stainless steel may be welded to the end of the pipe with the backing flange behind it.

In the cases 2 (*a*) and (*b*) the outside diameter of the annulus is $\frac{1}{4}$ in. or so less than (p.c.d. of bore circle minus diameter of the bolt hole), but in case 3 the outside diameter of the stainless-steel disc would be no more than $\frac{3}{4}$ in. larger than the outside diameter of the pipe itself. When bolting backing flanges together there is a considerable cantilever effect and this may be overcome either by using thick flanges or by welding stops on the outside edge of the face of one of a pair of flanges. The thickness of these stops should be very slightly less than the space left when the two pipes are jointed and the joint ring compressed, leaving room for error and thus ensuring that the pressure is on the joint rather than on the stops.

Many types of stainless-steel valves are used with equal success, but manufacturers sometimes have to contend with porous castings. This may be one of the reasons why stainless-steel valves are so expensive, and suggests that manufacturers would do well to hold stocks of this type of valve.

### Some problems and some solutions

Post-war developments have increased the demand for stainless-steel pumps and it is good to see manufacturers standardising on stainless-steel shafts where they can. In many instances they would no doubt be prepared to standardise on stainless-steel impellers and possibly bodies if the costs were reasonable, but the cost will never be reasonable until such time as the problem of porosity in castings is vigorously tackled and overcome. Normally the type of pump used in the chemical industry is quite small and, therefore, few fabricated centrifugal pumps are used.

Having broached the subject, it would seem to be an opportune moment to bring up the question of porous stainless-steel castings, as these are complementary to the fabricated equipment in many instances. As has already been stated, the castings used

for the conversion pot were excellent; these, of course, were spun-cast under carefully controlled conditions and have proved in every way to be very satisfactory.

As we all know, there is a need in this country to cut down costs wherever possible. This can be partially achieved by eliminating rejects and cutting down maintenance. It cannot be achieved unless the foundry industry can organise itself on sound lines, thereby cutting its own costs and those of its customers. In particular the industry must not waste the time of its customers by sending faulty castings.

There are some well-organised foundries in the country which are capable of turning out good castings. Their capacity is limited—our need is urgent. When, therefore, can we expect progressive action from the foundries working with antiquated and inefficient equipment and methods?

We in the chemical industry will be only too pleased if the foundries will approach us to tackle this question jointly if their problems are caused by our exacting requirements. As an industry we would like very much to standardise, for instance, on a stainless-steel-bodied pump throughout our works, but as long as a stainless-steel-bodied pump costs up to 200% more than cast iron or bronze there is little hope of such standardisation.

Stainless steel is more plentiful, although still in short supply due to the acute shortage of nickel. Manufacturers are more experienced in fabrication, manipulation and welding. Steel makers are continually developing new stainless irons and steels, giving varying degrees of resistance to corrosion and heat. Materials are being produced which can be fabricated and welded without recourse to heat treatment. The chemical industry is thus presented with a first-class opportunity of going ahead, but costs must be kept down all round if we are to be competitive.

It should be made clear, however, that stainless steel is not the final answer and is not a universal solution to all our corrosion problems. There are many difficulties which have not been mentioned.

We have learned a lot; we have a lot to learn. However, there is always a wealth of information available at the works where the steel is made and the stainless steel is fabricated, cast, forged or worked.

To sum up, stainless steel is so widely used today that it is doubtful in the chemical, pharmaceutical or food industries whether there is any item of equipment which is not or could not be fabricated in it. Nowadays it is so easy to weld, it can be so readily worked and there is such a choice of qualities that it is suitable for some 80% of everyday chemical manufacture.

Although it is relatively simple to fabricate equipment in stainless steel, much more care is required than in the case of mild steel. Nevertheless, most reputable manufacturers today are very competent in this field of work and very little trouble will be experienced if a careful check is made during construction and if badly made equipment is rejected. We in Monsanto have made it our practice to consult, wherever possible, with the steel makers or the fabricators to make sure that we are getting what we want; that the steel makers know what we want; and that what we ask for from fabricators is within their scope and fits in with their manufacturing techniques. We have found from experience that this method of working in very close co-operation benefits all concerned.

---

## Iron and steel encyclopædia

In the preface to this book* it is stated that its purpose is to provide a concise description of the materials, plant, tools and processes used in the iron and steel and closely allied industries. These are listed alphabetically with a brief descriptive paragraph, and a praiseworthy feature is that references are given to aid the reader in searching for further information. In addition to the main alphabetical encyclopædia and list of references, appendices containing conversion tables, weights and measures, metallurgical properties of certain steels, technical symbols and a list of scientific, technical and trade societies are included. It is specially valuable to have such a reference book coming from a U.K. source. Most general reference books available hitherto are of American origin and, because of the differences between the industries in the two countries, are inadequate in some respects for U.K. readers.

Miss Osborne has performed her difficult task admirably and has resolved very successfully the difficulty of being both complete and concise. The alphabetical list is remarkably comprehensive, though it is perhaps inevitable, in view of the origin of the book, that the finishing and special steel processes are dealt with rather more fully than the primary processes. For instance, a searcher for information on some of the terms used in iron ore technology such as 'bedding,' 'dragline,' 'Frodingham stone' and 'marlstone' would go unrewarded. At the other end of the industry, not all the terms commonly encountered in the tinplate trade are to be found.

On the other hand, chemical references are very fully represented and it may be questioned whether some of these, such as 'amines,' 'chelation,' 'conjugated system' and 'relative valency effect' need be included if this has been done at the expense of a few more of the practical terms in, say, blast furnace practice.

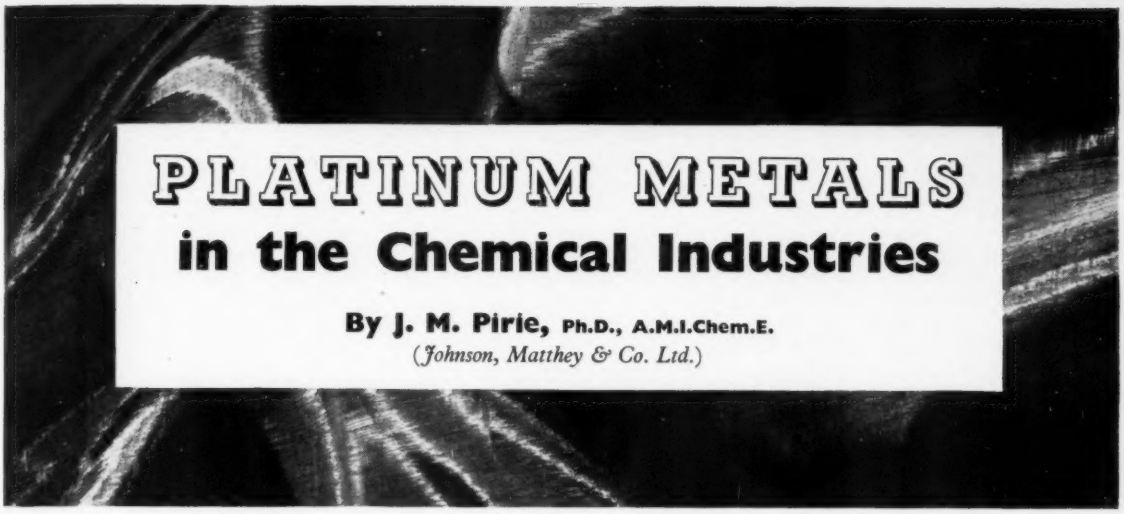
The general appearance of the book and typography are pleasing, and make for easy reference and reading. The illustrative plates are all drawn from the Sheffield special steel branch of the industry; although they might have been more representative, they serve their purpose well. It is a pity that a better sketch of an open-hearth furnace than that given on page 297 could not have been found to illustrate this reference.

One can hardly expect a comprehensive book of this kind to be entirely free from technical inaccuracies, but these appear to be very few and perhaps trivial. For example, refined pig iron is made mainly from remelted steel scrap and not pig iron, and the term 'Steckel mill' is also frequently applied to hot mills of a similar general pattern to the cold mill described under this title, but with driven rolls. Some processes are referred to under a proprietary name when, in fact, they are processes of a general character not specially associated with any one method of operation, nor group of patents.

The fact that a search for points to criticise has produced such a meagre harvest is sufficient evidence of the generally high standard of the book.

A. H. LECKIE

*An Encyclopædia of the Iron and Steel Industry, by A. K. Osborne. The Technical Press Ltd., London, 1956. Pp. 558. Illus. 90s. net.



# PLATINUM METALS
## in the Chemical Industries

**By J. M. Pirie, Ph.D., A.M.I.Chem.E.**
*(Johnson, Matthey & Co. Ltd.)*

THE six elements which occur together in native platinum have certain individual resemblances and are known collectively as the platinum metals. They fall into two distinct sub-groups, the light triad of ruthenium, rhodium and palladium and the heavy triad of osmium, iridium and platinum.

Of the six, platinum is by far the most useful and, fortunately, it is also the most widely distributed in nature. The platinum resources of the Western nations lie mainly in the copper nickel ores mined in Canada and South Africa, which are concentrated and treated to separate the copper-bearing and the nickel-bearing compounds. These are separately refined, and platinum metals are obtained from the anode slimes arising from the electrolytic recovery of nickel.

The properties of platinum are related to those of the other members of the group, but differ from those of any other metallic material. Platinum has a high melting point, 1,769°C., and is virtually immune to atmospheric oxidation to all temperatures up to the melting point. It can be melted and cast without any protective atmosphere. It is remarkably inert to chemical attack even up to very high temperatures and it is resistant to anodic oxidation under a wide range of acid conditions. By virtue of its chemical properties it is also a very effective catalyst for heterogeneous reactions, particularly those involving oxygen transfer.

**The title illustration shows rhodium platinum alloy ammonia oxidation gauze draped to demonstrate its softness and flexibility (see under 'Ammonia oxidation').**

The mechanical properties of pure platinum at room temperature are adequate without being in any way remarkable, but it retains a considerable proportion of its strength at high temperature. In a fully annealed condition its tensile strength is about 10 tons/sq.in. Heavy cold working increases this to about 15.5 tons/sq.in. Pure platinum is both malleable and ductile and can be easily rolled into foil or drawn into fine wire or tube. By alloying, particularly with other platinum-group metals with which it forms continuous series of solid solutions, a considerable increase in mechanical strength is possible. For example, annealed 10% rhodium platinum alloy has a tensile strength of about 20 tons/sq.in. at room temperature and 6 tons/sq.in. at 1,000°C.

Because of its unique properties, platinum has had a long association with the chemical and allied industries, although many of its early uses have been displaced by the development of cheaper or more suitable materials for particular purposes. However, these changes have been completely overborne by the continual development of new uses arising from technological advances and, in spite of a continual increase in both mining capacity and extractive facilities, the upsurge in industrial demand has only with difficulty been met.

### PAST AND PRESENT IN THE CHEMICAL INDUSTRIES

Probably the earliest known industrial application of platinum was by Sandeman at his Thames Bank chemical works, where in December 1809 he was using a concentrator having a capacity of about 300 lb. vitriol made from 423 oz. of platinum. The use of comparatively large platinum vessels for sulphuric acid concentration continued through the 19th century, and they only fell entirely out of use at the time when the acive development of the contact process led to a widespread new demand.

*Platinum is a metal whose value to the chemical engineer has become increasingly evident in recent years. This article reveals its surprising range of duties both as a material of construction and as a catalyst.*

Platinum is so much more costly than other materials employed in the chemical industries that it is obviously only applied when no other material will perform with adequate efficiency. Its uses are therefore solely guided by its technical properties, fundamentally its extreme inertness to oxidative attack.

Its present-day uses may be conveniently classified into those which are catalytic and those which are not. The non-catalytic or constructional

group can in turn be sub-divided into high-temperature and other uses. The glass industry offers a number of excellent examples of the employment of platinum in high-temperature services.

### Platinum in the glass industry

The manufacture of glass has traditionally been carried out in refractory or clay vessels or in tanks constructed of refractory bricks. While these materials are perfectly adequate for most purposes, there is always some degree of attack on the container which may introduce stone or some other contamination into the glass, and which may result in dimensional changes, particularly if the glass is flowing. For parts which have to be

**Fig. 1. A platinum crucible containing a charge of molten optical glass.**

accurately sized and where electrical conductivity is required, there are obvious advantages in a metallic constructional material. Platinum and its alloys are the only metals which can be exposed in air to glass-melting temperatures of, say, 1,200 to 1,400°C., and which are also unattacked by molten glass. Platinum was first introduced into this field for the manufacture of optical glass, where fairly long contact with the container is necessary during the homogenising period and where it is very important to avoid contamination. Single vessels of up to 20-l. capacity are at present in use for this purpose. In Fig. 1 a melt of optical glass is being poured from a platinum crucible.

In situations where the glass stream must flow through an orifice of fixed diameter, or where the presence of fragments of undissolved stone in the glass is particularly undesirable, the use of platinum sheathing for orifice rings, for gates, and for tank blocks is now becoming accepted practice. The problems in the manufacture of glass fibre are of a special kind, since here the glass must flow through a series of small, heated orifices. For this purpose the use of metal is essential and platinum has been universally adopted for the construction of the electrically heated furnaces used for this process. Since there are significant mechanical stresses sufficient to cause deformation of pure platinum at a temperature of 1,400°C., it has now become usual to manufacture these furnaces, or bushings, of 10% rhodium platinum alloy. The rhodium platinum alloy bushing shown in Fig. 2 is made for the production of continuous filament glass fibre.

### Electric resistance furnaces

The wire-wound resistance furnace is a most convenient small source of high temperature. For continuous temperatures above, say, 1,300°C., there are, however, no practicable winding materials except either a platinum alloy or molybdenum. The latter material can, of course, only be used in a protective atmosphere, so that molybdenum-wound furnaces tend to be somewhat complex in design and costly to operate. By the use of a winding of 10% rhodium platinum alloy, continuous working temperatures up to 1,500°C. can be maintained. With alloys of higher rhodium content, furnaces can be built for working temperatures up to 1,750°C. The tubular furnace shown in Fig. 3 is a recent design, intended as a standard for laboratory purposes, with available operating temperatures up to 1,500°C.

### Temperature measurement

A thermocouple provides by far the most convenient and accurate means of measuring elevated temperatures. The stability of platinum with its alloys at high temperature, as well as their availability in extremely pure form, make them admirable materials for this purpose, and the platinum rhodium platinum thermocouple has become the accepted means of accurate measurement of temperatures above 1,000°C. Its principal applications are in the metallurgical, refractory and glass industries. The couple may be protected from furnace gases or from contact with molten glass by the use of a platinum or platinum alloy sheath; in determining the temperature of liquid steel a thin-walled silica sheath is used which enables a very rapid response to be obtained. By the 'quick immersion' technique, liquid steel temperatures up to 1,650°C. can be accurately measured. Fig. 4 shows the use of a rhodium platinum thermocouple for a 'quick immersion' measurement in a Bessemer converter.

### Miscellaneous high-temperature uses

The remarkable resistance of platinum to fluorine compounds at high temperatures has enabled use to be made of pyrolysis reactions for the preparation of organic fluorine compounds. In one example, 1-in. bore flanged *Inconel* tubes, with solid-drawn platinum liners 0.02-in. thick, are embodied in a reaction system operating continuously at about 700°C.

### Some other non-catalytic uses

Apart from its extensive employment in laboratory apparatus and electrodes, which is outside the scope of this article, perhaps the most important non-catalytic use of platinum and its alloys in the chemical industry is in the manufacture of insoluble anodes for electro-chemical processes. The main problem in anode design is to provide sufficient area of contact with the electrolyte, and also to provide adequate current-carrying capacity, without employing an undue weight of metal. A large number of ingenious designs have been evolved for this purpose, some employing very fine wire or net connected to current systems protected by a plastic material, others employing very thin foil attached to the surface of a base metal conductor. Perhaps the most successful anodes devised for this purpose are of rod form, comprising a central copper or silver core sheathed with a very thin-walled platinum tube. By extremely careful control of tube-drawing conditions, it is possible to produce tubing with a wall thickness of only 0.002 in. which is completely free from inclusions of pinholes; it was only when this became possible that the cored rod-type anode became a practical success. Anodes of this type are used in a number of electro-chemical operations; the manufacture of persulphates are an intermediate step in producing hydrogen peroxide, and the manufacture of bromates, are typical examples.

Platinum-wire electrodes and platinum-sheathed rod-type electrodes are beginning to find use in cathodic protection techniques, in installations where the impressed current system is preferable and where a compact insoluble anode is necessary, able to operate at high current density. Although comparatively recent, this application offers the possibility of important economic advantages in such fields as the internal protection of vessels and pipelines, or the external protection of ships' hulls.

Another long-established use of platinum, usually for this purpose alloyed with gold or rhodium, is in the viscose rayon industry, where the spinning process presents an unusual combination of both highly alkaline and acid conditions, and where the spinnerettes must be provided with a multiplicity of very small holes accurately sized and highly polished. Tantalum is the only alternative material which has been employed in this process, and in most cases after initial trial users have reverted to platinum alloy jets.

## CATALYTIC USES OF THE PLATINUM METALS

### The contact process

The effect of a platinum surface in promoting the combination of hydrogen and oxygen was noted by Michael Faraday. A patent was taken out as early as 1831 by Peregrine Philips for the manufacture of sulphur trioxide by drawing sulphur dioxide and oxygen through a heated tube containing platinum sponge. This process was brought into commercial use about 1878, but it was not until the equilibrium studies of Knietsch established the correct conditions of reaction that a successful industrial process was achieved. Thereafter progress was extremely rapid and by 1920 many thousands of ounces of platinum were in use in sulphuric acid contact plant. The subsequent development of catalysts based on vanadium pentoxide which under some conditions had both technical and commercial advantages has considerably diminished the quantity of platinum employed in the sulphuric acid industry, although a substantial number of metallurgical gas plants still employ platinum, usually on a silica-gel base.

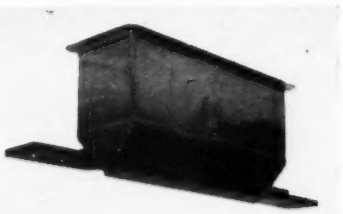


**Fig. 2. A rhodium platinum alloy bushing for the manufacture of continuous filament glass fibre.**

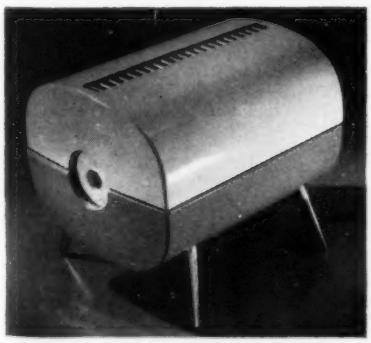


**Fig. 3. A standard tubular high temperature resistance furnace wound with 10% rhodium platinum alloy wire.**

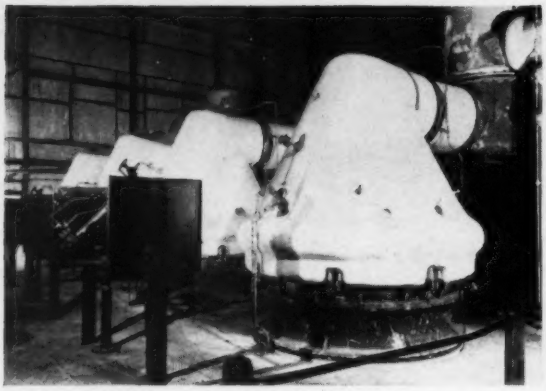
**Fig. 4. A platinum/13% rhodium platinum thermocouple in use in a Bessemer converter.**

### Ammonia oxidation

During the period of early expansion of the contact process, the second great platinum-using catalytic process was also developed; the oxidation of ammonia with air as a direct means of making nitric acid.

The equilibrium conditions for ammonia conversion are quite different from those applying to the oxidation of sulphur dioxide, where bulky catalyst permitting a long contact time is necessary. In ammonia oxidation, equilibrium is attained extremely rapidly and it is then necessary to remove the products from the reaction zone in order to prevent decomposition of the nitrogen oxides. Consequently a wire gauze catalyst pad is employed, mounted transversely in the gas stream. The gauze must be heated to initiate the reaction; thereafter it is maintained at temperature by the heat evolved. Some idea of the softness and flexibility of the fine wire gauze woven for this purpose is shown in the illustration surrounding the title heading of this article.

The early plants were equipped with pads of pure platinum gauzes and were operated at approximately atmospheric pressure. Although the process still continues unchanged in principle and is now the source of virtually all the world's nitric acid, techniques have developed along two divergent lines. On the one hand, in order to increase absorption efficiency without having to compress the oxidised gas, a method of operating the oxidation unit itself at a pressure of about 100 p.s.i. has come into use. In this process the catalyst is made up into a relatively thick pad of 40 to 50 gauzes nearly always of 10% rhodium platinum alloy. This alloy is used because under high pressure it is necessary to operate at a higher temperature to obtain the same conversion efficiency, and the rhodium platinum alloys have a considerably smaller high-temperature-loss rate than has pure platinum. A different technique has been adopted in continental Europe, where atmospheric



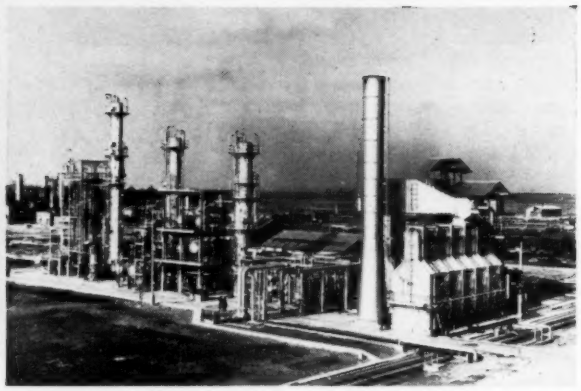


**Fig. 5** (*Left*). **Two-metre diameter ammonia burners of Bamag design in a Ministry of Supply factory. Fig. 6** (*Right*). **A 'Platforming' (platinum catalyst reforming) unit at the Kent oil refinery of British Petroleum Ltd.**

pressure oxidation has continued, often combined with compression of the oxidised gases before absorption. In order to provide high thermal efficiency and low operating cost, the size of individual converters has been increased, until a number are now in use employing circular gauzes 3 m. in diameter, usually mounted directly over a waste-heat boiler of the La Mont type. Fig. 5 shows a range of 2-m.-diam. Bamag converters in a Ministry of Supply factory. These large gauzes are still occasionally made of pure platinum, but more commonly they are of 3 or 5% rhodium platinum alloy.

Similar oxidation units, but of very much smaller size, are also employed to furnish nitrogen oxides for the sulphuric acid chamber process.

### Petroleum reforming

A most important post-war advance in the catalytic use of platinum has occurred in the petroleum refining industry, where the development by Haensel and his co-workers of a method of catalytically reforming hydrocarbon molecules by vapour-phase treatment with a combined catalyst comprising an active base impregnated with a small proportion of platinum has been outstandingly successful.

The original *Platforming* process developed by Universal Oil Products has been rapidly followed by a number of others and, at the present time, the installed capacity of reforming units in the United States alone is approaching 1 million bbl./day. All these processes employ a bulky catalyst, often having an alumina base, carrying a small proportion—usually about 0.5% —of finely dispersed platinum. By passing a vaporised petroleum fraction of narrow boiling range preheated to high temperature and under pressure through a series of reactors charged with this catalyst, considerable molecular rearrangement may be brought about, including the dehydrogenation of six-membered ring naphthenes, the dehydro-isomerisation of five-membered naphthenes and the dehydrocyclisation of paraffins.

A product is obtained having a considerable enhanced octane rating, as well as a useful quantity of hydrogen. By modification of the feed stock and changes in operating conditions, the process can be made a rich source of aromatic chemicals. Even higher-octane ratings can be obtained if required by solvent extraction accompanied by partial recycling. Similar catalytic processes are also being developed for isomerisation of the lighter fractions which are recovered by stripping natural gas. Fig. 6 shows a *Platforming* unit at the Kent Oil Refinery of the British Petroleum Co. which has an annual throughput of approximately 250,000 tons.

### Catalytic combustion

One of the older uses, particularly of platinum on asbestos, is as a convenient source of relatively low-temperature heat, which may be obtained by the catalytic combustion of a petroleum spirit of fairly high flash point at the surface of the active catalyst. More recently, some success has been achieved in the development of supported platinum catalysts by means of which fumes carrying organic vapours or carbon monoxide can be burnt even in a very large excess of air. The catalyst is dispersed on a refractory material or a heat-resistant metal foil and is arranged so that it has low resistance to rapid gas flow.

### Palladium catalysts

Palladium, particularly when it is finely dispersed on the surface of an active carrier, forms an extremely effective hydrogenation catalyst. On a moderate scale, it is widely used for liquid-phase hydrogenation reactions in the manufacture of medicinal compounds. The conversion of adrenalone to adrenalin and the preparation of dihydro-streptomycin are typical examples.

A very large quantity of palladium of silica-gel catalyst was employed in Germany for the manufacture of 5,000 tons of ethylene per month from acetylene. With the ready availability of ethylene from petroleum-refining operations this process has fallen out of use, but similar catalysts are employed in the purification of ethylene from traces of acetylene. Palladium on alumina catalysts are also very widely used for the purification of hydrogen by the catalytic combination of the residual oxygen content. Other metals of the platinum group, notably ruthenium, have important potential catalytic uses, although these have not yet been developed commercially.

### Future prospects

In this brief survey, only the most noteworthy of the extraordinary range of uses of the platinum metals in the process industries have been discussed. There are a number of other catalytic processes, for example, the manufacture of hydrogen cyanide from methane and ammonia, which are only now becoming of industrial importance.

The rapid changes in chemical technology will undoubtedly bring about less costly alternatives for some of the applications for which platinum metals are now employed. On the other hand, their inherent properties, particularly the ability of platinum to resist high-temperature oxidising conditions, and

(*Concluded on page* 18)

# METALLURGY

**By H. A. Holden, M.Sc., A.R.C.S., D.I.C., A.I.M.**

***Advances in the development and uses of steels and their alloys; magnesium; titanium; and miscellaneous other metals***

FERROUS metallurgical progress should clearly take pride of place in this report as 1956 was celebrated as the Bessemer centenary year. It was at Cheltenham just over 100 years ago that on August 11, 1856, Mr. Henry Bessemer told of his new method of making steel—a discovery which ranks amongst the most important in the history of mankind. Bessemer and his work have recently been the subject of many papers and articles[1, 2] and, to commemorate him, the British Iron & Steel Federation in co-operation with the Science Museum is composing a new metallurgical display in the museum which should be completed in three years' time.

***A CPE chemical engineering review***

### Structural steel

One of the major applications for steel is as a structural material and its protection against corrosion is very much the concern of the engineer, chemist, metallurgist, and chemical engineer alike. It is appropriate, therefore, that details were published at the beginning of the period under review of a symposium on 'The Protection of Structural Steel' held by the Corrosion Group of the Society of Chemical Industry. The papers were broadly divided into two main groups, namely 'Practical Experience' and 'Comparative Tests' and, in the former, those by Himsworth[3] and Ravald,[4] dealing with the protection of steelwork in chemical factories and the preservation of steel on gas works respectively, are of considerable interest to chemical engineers. A similar type of information, although not presented at the symposium, has been given by Radecke[5] on a successful maintenance painting programme for a refinery. Current good painting practice for steel structures in the U.S. was reviewed by Bigos,[6] whilst Fancutt[7] discussed in some detail a code of practice introduced by the British Transport Commission covering the cleaning and painting of bridges, buildings and structures. Lastly, on the practical side, Ballard and Rivett[8] described experiences of protection by metal-sprayed coatings using the wire and powder processes, respectively, with considerable attention being paid to economics.

In the group dealing with comparative tests, results obtained by the Swedish Committee on Corrosion with painted and galvanised surfaces, by the Corrosion Committee of the A.B.E.M. and the Joint Technical Panel J/P1 of the Protective Coatings (Corrosion) Sub-Committee of the British Iron and Steel Research Association[9] were presented. The interim results of the extensive programme undertaken by the B.I.S.R.A. Sub-Committee showed that, for weathered steel, priming paints in a linseed-oil medium proved better than those in all other media tested and one pigmented with a mixture of red lead, white lead and asbestine was recommended. Good results were also obtained with priming paints pigmented with aluminium powder, basic lead sulphate or zinc oxide, with or without asbestine, in an alkyd medium and by pigmented paints derived from blends of the natural bitumen, gilsonite and various drying oils.

In addition to the above, the protection of steel surfaces by sprayed aluminium coatings has been studied by Evans,[10] who has described an experiment demonstrating that such coatings can afford cathodic protection. Champion[11] has discussed the characteristics of both sprayed zinc and aluminium coatings on steel at ordinary and elevated temperatures in relation to the recent British Standard Specification 2569; and Schofield[12] has reviewed the whole subject of maintenance painting in the steel industry.

### Steels and alloys in service

One of the most important applications of the austenitic chromium-nickel steels of the 18/8 type containing titanium is for chemical plant fabricated by welding and used for handling concentrated nitric acid liquors. The welded joints in such equipment, in addition to having the requisite strength and soundness to carry the mechanical loads involved, must also have adequate corrosion resistance. Fortunately, little difficulty is experienced in producing satisfactory welds, but the application of a fusion-welding process to these steels may have a detrimental effect on the corrosion resistance of the parts of the parent metal heated during welding. This problem has been investigated by Heeley and Little,[13] who found that reduced corrosion resistance resulted from heating to temperatures in two ranges, namely (*a*) 600 to 750°C. and/or (*b*) about 1,300°C. Titanium content is a most important

[*Courtesy: F. W. Berk & Co. Ltd. (Schori Division)*

**Zinc spraying a centrifuge basket.**

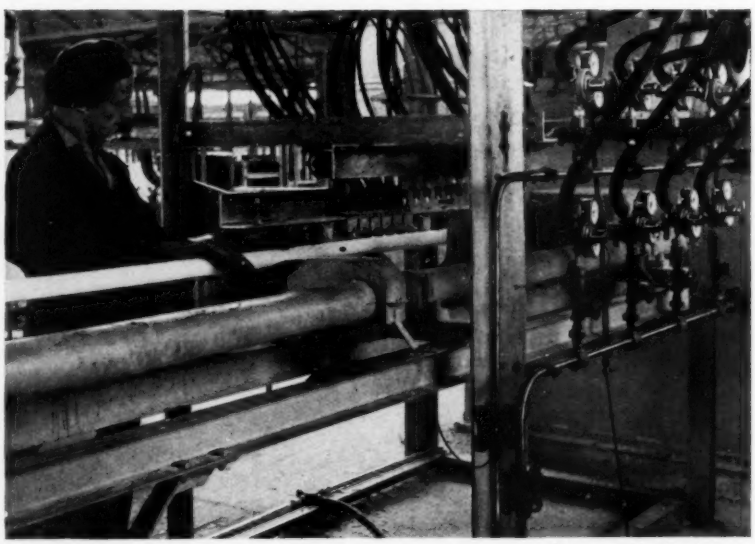
factor and they demonstrated that 18/8/Ti steels having $\geq 0.06\%$ C and an adequate Ti/C ratio were almost completely immune from temperature impairment of corrosion resistance in both temperature ranges. Molybdenum-containing alloys are considered by Briggs[14] to hold future advantages for specific applications in the chemical industry. The particular types discussed are (1) austenitic Cr-Ni steels containing Mo (~18% Cr and 8% Ni), (2) austenitic Cr-Ni steels containing Mo and Cu (~20% Cr, 30% Ni, 2.5% Mo and 3.5% Cu), (3) high-Si irons containing Mo (~14% Si and 3% Mo) and (4) Ni-base alloys containing Mo. The selection of metallic materials for handling aqueous hydrofluoric acid always presents a difficult problem, particularly where joints are concerned. The investigation of Schussler[15] into the corrosion resistance of joints of materials commonly used for handling this acid is therefore of considerable practical importance. The materials tested included cold-rolled *Monel*, annealed *Monel*, cold-rolled Cu-Ni, annealed Cu-Ni (70% Cu, 30% Ni), *Illium R*, commercially pure lead and silver. Using 48 and 5% H.F. w./w. solutions, the results showed that *Monel* and Cu-Ni exhibited low corrosion rates when totally immersed and either welded or brazed joints were satisfactory. Of the metals tested only silver offered superior resistance to attack at and above the liquid-level line. Still on the subject of materials for chemical plant, Peters[16] has reviewed the potentialities of clad steels and Hinle[17] has described the different welding procedures applicable to clad steels including nickel-, *Monel*-, *Inconel*- or stainless-clad steel.

Metals for high-temperature service are always news. In this connection chemical engineers will find information recently published by the National Association of Corrosion Engineers (Technical Unit Committee T-5B) particularly valuable.[18] Corrosion rates are listed as 'high,' 'moderate' or 'low' for 31 materials in over 60 corrosive media at temperatures >400°F. These include mild steel, cast iron, Ni-resist, 4-6 Cr-Mo and 21 Cr-4Al steels; three Cr steels; three Cr-Ni steels, two Cr-Ni-Mo steels; silicon iron and *Durimet* 20. Shirley[19] has examined the effects of sulphate-chloride mixtures in fuel-ash corrosion of heat-resisting steels and high-nickel alloys at about 700°C. Severe attack on such metals in equipment handling ash and combustion products of peat and oil fuels was found to be associated with sulphur absorption. Although resulting from contact with alkali and alkaline-earth sulphates contaminated with chloride it was not caused by direct absorption of sulphur from gaseous products of combustion. Marshall and Sinclair[20] have examined numerous constructioned materials for resistance to smoke, steam and direct funnel blast from coal- and oil-burning locomotives. Molybdenum-bearing austenitic stainless steel and vitreous enamelled steel both proved very resistant to these conditions. A very useful graphical summary of the elevated temperature strength data for C-steels has been published by the American Society for Testing Materials.[21] This includes summary curves for tensile strength; 0.2% offset yield strength; % elongation and reduction of area; stresses for rupture in 100, 1,000, 10,000 and 100,000 hr., and stresses for creep rates of 1% in 10,000 and 100,000 hr.

Everhart[22] has reviewed the many satisfactory applications of grey cast irons (particularly alloyed compositions) for high-temperature service. For example, alloyed irons with tensile strengths of up to 50,000 p.s.i. are used for cylinder blocks, liners and heads, steam-control valves, furnace liners, stokers and grates, etc. Galletto[23] has also drawn attention to the resistance to oxidation and expansion and the creep strength of plain high-Si and high-Ni austenitic spheroidal graphite cast irons which make it possible to use these materials in place of more expensive metals. He has demonstrated that their oxidation resistance is comparable to that of 12% Cr stainless steel and their use is recommended for long-term load-carrying applications at 540 to 595°C. when both spalling and creep resistance are required. He suggests that austenitic spheroidal graphite cast irons can be employed up to temperatures of 705°C. and even higher when loading is not excessive.

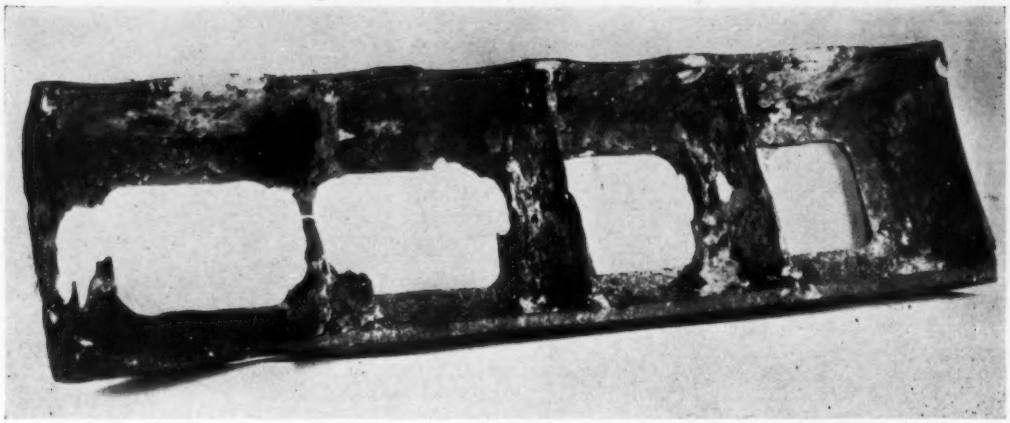
### New steels, irons and heat-resisting alloys

A new constructional plate steel developed by the United States Steel Corporation[24] is USS T-1, supplied in the thickness range $\frac{1}{4}$ to 6 in. to meet a minimum tensile strength specification of 105,000 p.s.i. after quenching and tempering. A typical composition is 0.15% C, 0.75% Mn, 0.24% Si, 0.85% Ni, 0.50% Cr, 0.45% Mo, 0.005% V, 0.31% Cu, 0.003% B, S and P below 0.03%. Estes and Schneidewind[25] have described the development of a class of high-strength cast irons intermediate in properties between normal grey cast iron and nodular iron. They are produced by injecting a mixture of calcium carbide and rare-earth oxides with or without MgO; 20 to 40% of the graphite is nodular, the remainder being present as short, stubby flakes. Advantages are high strength, ductility, insensitivity to changes in section



[*Courtesy: Metallisation Ltd.*

**A tube spraying machine in which twelve nozzles are ganged together in two banks. Grit blasting by 'Wheelabrator' and spraying are carried out in close proximity on a common spiral conveyor.**



[*Courtesy: J. Iron & Steel Inst.*

**Heavily attacked 25/20 Cr-Ni steel superheater support encrusted with sodium sulphate.**[19]

size, low chill depth and low solidification shrinkage. A new series of carburising steels with molybdenum as chief alloying element have also been reported.[26] Quenched directly from carburising, they combine high case hardness with optimum wear resistance and are claimed to be showing promise in gear performance tests. In view of the world nickel shortage, the reported development of a new nickel-free stainless steel, also by United States Steel Corporation, is of considerable topical interest.[27] After many experiments adjusting Cr, Ni and nitrogen contents, compositions were found where high nitrogen contents could be held to maintain the stability of austenite up to 2,300°F. New high-temperature alloys both low in strategic materials and both designed for turbine-bucket applications are *Jetalloy* 1570[28] and GMR-235.[29] The former contains Co 36.9 to 38.5, Ni 27.7 to 28.5, Cr 19.7 to 20.4, W 6.3 to 7.3, Ti 4 to 4.5, Fe 1.5 to 2.8 and C 0.17 to 0.27%, and the latter is a nickel-base alloy with the other major constituents being Cr 14 to 17, Fe 8 to 12, Mo 4.5 to 6, Al 2.5 to 3.5 and Ti 1.5 to 2.5%.

## Metallography and analysis

Progress in all fields of metallurgical analysis has been reviewed in an excellent paper by Jaudon[30] which includes 91 references to the literature. In one small sphere of this subject, Philibert and Crussard[31] have described experiences at the Institut de Recherches de la Sidérurgie with the Castaing-O.N.E.R.A. electron probe microanalyser which enables elementary point analyses to be made (over an area of 1 to 2μ diameter) of all elements of atomic number >17, with an error of 1%. Developments in metallographic techniques include a new type of polishing machine in which the micro-specimen rests on a board and is guided by a ring which is itself near to the board.[32] Several specimens can be polished simultaneously and pressure adjusted by weighting the sample. Porous powder compacts, materials containing a large number of non-metallic inclusions and polyphase alloys with marked difference in hardness between the phases are, however, typical of materials which cannot be prepared for microscopical examination by conventional polishing methods. These are normally polished by methods employing diamond dust, and lead or wax laps, etc. Haddrell, Sykes and Mott[33] have investigated the use of plastic laps for such purposes and have found that polythene-bonded laps provide a useful means of preparing specimens, particularly in the final stages. Also, polythene discs covered with terylene fabric are very suitable for attack polishing and provide a suitable alternative to electrolytic polishing. To facilitate metallographic examination, new etching agents for certain types of ferritic, semi-ferritic, martensitic and austenitic stainless steels have been investigated.[34] One contains ethyl alcohol, acetic, hydrochloric and picric acids; and another contains nitric, hydrochloric, hydrofluoric and acetic acids.

## Magnesium

Of the non-ferrous metals, titanium tends to get most of the publicity, but the uses of aluminium continue to expand very rapidly, particularly in engineering fields. Another light metal which is steadily increasing in usage is magnesium—the eighth most abundant element and the sixth most abundant metal in the earth's crust. The presidential address to the Institute of Metals this year was devoted to this metal[35] and the trends disclosed, although perhaps not startling, are certainly significant. World War 2 created a marked increase in the demand for magnesium; for example, the approximate total quantity produced by all countries for the period March 1939-40 was 32,000 tons. The comparable figure for the period 1943-44 was 228,000 tons, but the valuable properties of the metal for civilian purposes were so little appreciated that by 1946 world production of the pure metal was back to 10,000 tons p.a. Applications, probably based on confidence gained in the metal during the war, have been steadily increasing during the last 10 years so that by 1955 world production had risen to approximately 124,000 tons. Of this the U.S. consumption was 65,000 tons (53% civilian/47% defence purposes) and it is forecast that this consumption will rise to 100,000 tons by 1960.

Magnesium weighs one-third less than aluminium, but is not sufficiently strong to be used by itself for engineering purposes, and alloys of magnesium are therefore employed. Some of the outstanding applications for these are as aircraft landing wheels (approximately 1 million cast for British aviation alone during the war), the 36 lb. of magnesium castings used in the engine of the *Volkswagen* car,[36] the 52-lb. transmission case for the Standard Ferguson tractor, and in the Vickers *Viscount* which carries 82 ZREI (Zr-Zn-rare earths) castings. Wrought magnesium is being used in greater quantities for parts of aircraft fuselage and wings; thick sheet is being used for heavy-vehicle bodies and mag-

nesium anodes are widely used for the cathodic protection of iron and steel. Magnesium surfaces are not highly corrosion resistant and details have been published of a new coating process developed at Frankford Arsenal, U.S.[37] This Cr-22 coating is claimed to be a fine-grained green material resembling unglazed ceramic ware in texture which can be used as a base for organic finishes or as a final finish with or without an inorganic seal. The process consists of electrolytic treatment for ~12 min. using a.c. in a solution containing $CrO_3$ 25 g./l.; 50% HF 25 ml./l.; 85% $H_3PO_4$ 50 ml./l.; $NH_3$ 160 to 180 ml./l.

### Titanium

So much is published about titanium that it is only possible, in a report of this nature, to select from the literature a few items which are of interest to engineers. Lippert[38] has reviewed the development of the titanium industry in America during 1954 when production was more than double that of the previous year; the Armour Research Foundation has announced a new titanium-aluminium-vanadium alloy considered to be of promise in such applications as airframes, jet engines and ordnance;[39] new information has been released on the working of titanium and its alloys (welding, forming, forging and machining,[40] extrusion,[41] and wire drawing[42]); and results have been reported on tests to determine the corrosion resistance of the metal in hydrochloric and sulphuric acids,[43] nitric acid,[44] formic, acetic and chromic acids.[45] Descaling has received considerable attention. Lenning, Craighead and Jaffee[46] have reported significant hydrogen absorption of commercial titanium and an 8% Mn alloy when descaled in a molten sodium hydride or nitric/hydrofluoric acid bath. To overcome this in the latter a modified solution consisting of HF, HBF, NaF or $NaBF_4$ with >20% $HNO_3$ has been recommended by Bomberger, Vordahl and Finlay,[47] and a modified sodium hydride bath, which is claimed to reduce hydrogen pick-up, has been described by Alexander, Farrell and Wheatley.[48]

### Miscellaneous

New developments in **metal finishing** include the introduction of processes for the electroless deposition of chromium,[49] a new solderable zinc-alloy plating process,[50] the deposition of metallic and composite coatings by electrophoresis,[51] and *Gyro-finishing*.[52] This is a development of barrel finishing in which parts are polished before plating by submerging them in a revolving mass of free abrasive material. The components are held rigidly from outside to ensure adequate movement of abrasive over the metal surface and there is no tumbling action. It is claimed that a satisfactory finish can be produced in a few seconds with a speed of flow of abrasive past the surface of 1,500 to 1,800 ft./min.

As regards **joining,** Rose and Lewis[53] have discussed the high-temperature alloy brazing of thin materials for jet engines using alloy brazing powders (in particular A.W.S.-A.S.T.M. BNiCr filler material and A.M.S. 4775 material). The relatively wide solidus-liquidus range (1,850 to 1,950°F.) and the erosive penetration and alloying of the parent metals by the brazing material were found to be of great importance. Tests by Bredzs and Canonico[54] have shown that lithium appears to be the most promising metal for developing self-fluxing brazing alloys. Lithium additions not only reduced the oxides on steel surfaces, but also considerably lowered the wetting angle of molten silver.

**Other new processes or techniques** include the Fradecal[55] electrolytic descaling process for iron and steel; the painting of steel sheets with a 0.2% potassium dichromate solution to prevent the welding together of low-C rimming steel heated to below Ac,[56] the carbonising of steel in a molten mixture of sodium carbonate and titanium dioxide which produced a fine structure;[57] and the application of surface hardening by the nitriding process to forging dies to improve die life. Increased forging die life as high as 400% is quoted.[58]


REFERENCES

[1]*J. Iron & Steel Inst.*, 1956, **183** (2), 179-197.
[2]*Ibid.*, 1956, **184** (2), 113-121.
[3]*Chem. Indust.*, Dec. 10, 1955, 1618-1622.
[4]*Ibid.*, Nov. 26, 1955, 1526-1535.
[5]*Corrosion*, 1955, **11** (10), 39-43.
[6]*Chem. Indust.*, Nov. 19, 1955, 1503-1510.
[7]*Ibid.*, 1492-1502.
[8]*Ibid.*, Dec. 10, 1955, 1606-1615.
[9]*J. Appl. Chem.*, 1955, **5**, 173-188.
[10]*Chem. Indust.*, Mar. 24, 1956, 195-196.
[11]*Electroplating*, 1955, **8** (5), 180-182, 189.
[12]*Iron Steel Eng.*, 1955, **32** (9), 65-73.
[13]*J. Iron and Steel Inst.*, 1956, **182** (3), 241-255.
[14]*Indust. & Eng. Chem.*, 1955, **47** (8), 1513-1516.
[15]*Ibid.*, (1), 133-139.
[16]*Chem. Eng.*, 1955, **62** (10), 234-242.
[17]*Welding Metal Fab.*, 1956, **24** (1), 11-15; (2), 59-62.
[18]*Corrosion*, 1955, **11** (5), 59-63.
[19]*J. Iron & Steel Inst.*, 1956, **182** (2), 144-153.
[20]*Corrosion*, 1955, **11** (9), 31-34.
[21]Amer. Soc. Test. Mat. Spec. Tech. Pub., No. 180, Sept. 1955.
[22]*Mat. Methods*, 1955, **41** (2), 90-93.
[23]*Ing. Mecc.*, 1955, **4** (6), 25-33.
[24]*Mat. Methods*, 1955, **41** (1), 102-106.
[25]Amer. Found. Soc., preprint, No. 28, 1955.
[26]*Iron Age*, Feb. 9, 1955, **177,** 92-95; Feb. 23, 96-100.
[27]*Steel*, Nov. 7, 1955, **137,** 138-144.
[28]*Iron Age*, 1955, **176** (16), 116-118.
[29]*S.A.E. Journal*, 1955, **63** (8), 36-38.
[30]*Chim. analyt.*, 1955, **37** (2), 45-52.
[31]*J. Iron & Steel Inst.*, 1956, **183** (1), 42-47.
[32]*Fern. Kontorets Ann.*, 1954, **138** (8), 490-494.
[33]*J. Inst. Met.*, 1956, **84** (5), 112-114.
[34]*Met. Ital.*, 1955, **47** (1), 19-20.
[35]*J. Inst. Met.*, 1956, **84** (2), 399-411.
[36]*Metal Ind.*, 1955, **87** (23), 469-470.
[37]*Metal Finishing*, 1955, **53** (12), 57-59.
[38]*Z. Metallkunde*, 1955, **46** (7), 487-488.
[39]*Metal Treatment*, 1955, **22** (121), 430-431.
[40]*S.A.E. Journal*, 1955, **63** (6), 57-58.
[41]*Iron Age*, 1955, **176** (17), 81-84.
[42]*Wire & Wire Products*, 1955, **30** (10), 1246-1247.
[43]*Mat. Methods*, 1954, **40** (5), 106-108.
[44]U.S. Bur. Mines, Inform. Circ. No. 7711, 1955, 34 pp.
[45]*Techn. Mitt. Krupp*, 1955, **13** (2), 44-47.
[46]*Trans. Amer. Soc. Metals*, preprint, 1955, **48** (33), 10 pp.
[47]*Mat. Methods*, 1954, **68** (2), 114-116.
[48]*Metal Progress*, 1956, **69** (2), 78-80.
[49]*Metal Finishing*, 1955, **53** (7), 62-63.
[50]*Sylvania Technologist*, 1955, **8,** 3-6.
[51]*Plating*, 1955, **42** (10), 1255-1258.
[52]*Gen. Motors Eng. J.*, 1956, **3** (3), 64-68.
[53]*Welding J.*, 1955, **34** (1), 30-39.
[54]*Ibid.*, 1955, **34** (11), 535s-543s.
[55]*Usine Nouvelle*, 1955, **11** (8), 18, 39.
[56]*Stal.*, 1955, (4), 371-372.
[57]*Pruce Instytutow Mech.*, 1954, **4** (12), 23-35.
[58]*Metal Treating*, Jan.-Feb. 1955, **6** (14), 16-17.


## Platinum Metals in the Chemical Industries

(*Concluded from page* 14)

the remarkable catalytic activity of both platinum and palladium, will undoubtedly find increasing uses, the former possibly in combustion devices for heat engines, and the latter certainly from the increasing emphasis of continuous high-temperature catalytic processes in the manufacture of chemical products of all kinds. Initial cost is largely offset by high recovery value, and the economic practicability of the use of platinum in the bulk manufacture of low-cost products has certainly been demonstrated during recent years.

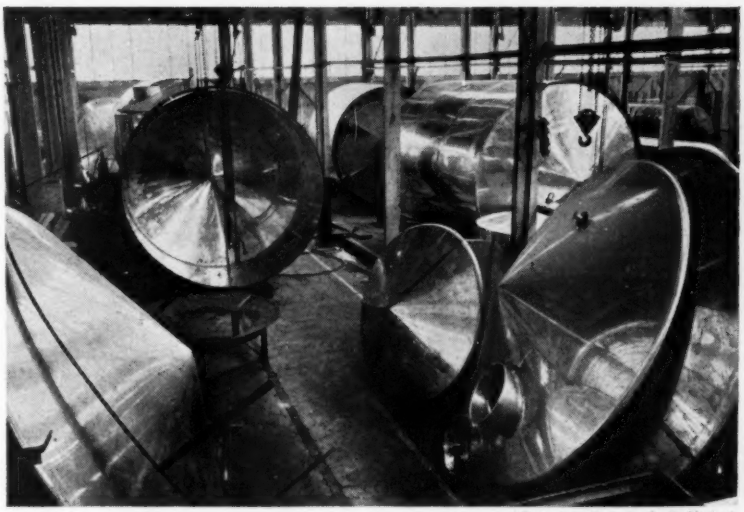
**Zinc knowledge.** The Zinc Development Association, 34 Berkeley Square, London, W.1, issues each month a review of recent technical literature on the various uses of zinc and its products, together with some other material of related interest. Short abstracts of the more interesting items are included.

# ALUMINIUM AND ITS ALLOYS in Chemical Engineering

**By E. Elliott, A.Met., F.I.M.**
(*The Aluminium Development Association*)

*After briefly reviewing the various forms of aluminium and its alloys available the author goes on to discuss the latest developments in the application of these metals to chemical engineering needs.*

IT was during the first decade of the present century that the first methods of joining aluminium by fusion welding were introduced, having been developed for the purpose of making food and chemical plant from sheet and plate. Since those days, the chemical-manufacturing and -using industries have continued to employ the metal and its alloys and, despite the rise of competitive corrosion-resisting materials, the special properties of aluminium have maintained its superiority in many processes.



[*Courtesy: Burnett & Rolfe Ltd.*
**Aluminium storage tanks under construction.**

## Properties of the metal and its alloys

Although aluminium is a highly reactive metal chemically, its high corrosion resistance is well known; this is due to the ever-present oxide film upon the metal's surface. This film is self-healing so long as oxygen or water are available, and is normally about $10^{-5}$ mm. in thickness. It is soluble in certain strong acids and alkalis, but largely inert to many chemicals and to the atmosphere. It is, of course, this factor which is the principal attraction of aluminium to the chemical engineer.

The high thermal conductivity of aluminium is valuable in heat exchangers and in chemical vessels which have to be externally heated such as boiling pans and sterilising plant; similarly, good heat transfer is important in refrigeration plant and condensers. Paradoxically enough, although aluminium is a good conductor of heat, the surface of the metal is highly reflective to radiant heat, so that aluminium vessels absorb the sun's heat only slowly, thus reducing evaporation losses. This property has led to the use of aluminium in foil and thin sheet for insulation purposes and also as a cladding for insulated pipes.

Even where very slight attack of certain plant may be acceptable to the chemical engineer, corrosion products often spoil chemicals where colour is important, and here the colourless nature of the salts of aluminium is a considerable advantage. Long experience and several scientific investigations have established the non-toxicity of aluminium, so that it represents no danger to pharmaceutical products; the smooth hygienic surface of the metal affords no lodgement to contaminants and is readily cleaned. Besides being non-toxic to higher animals, the metal does not destroy vitamins nor the bacteria used in processes for the manufacture of products such as antibiotics and citric acid. Similarly, yeasts are unaffected by aluminium.

No reference has yet been made to the major attraction of aluminium, apart from its corrosion resistance, namely its lightness. The specific gravity of the metal is about one-third that of the common engineering metals, which is particularly advantageous where heavy plant has to be erected, perhaps in remote areas, and obviously reduces the costs of transport, not only of plant but of chemicals carried in aluminium containers.

## Stronger alloys

Lightness, however, must be combined with strength if the demands of the engineer are to be met. By far the greatest usage of aluminium in chemical engineering has been and continues to be of metal of not less than 99.5% purity; the strength of this material is not high but is adequate for a great variety of applications.

Interest has increased in the chemical field since the war in alloys which, while of considerably greater strength than the pure metal, also approach its high corrosion resistance. Thus, about 1¼% of manganese may be added to aluminium with virtually no deleterious effect on durability; indeed with certain corrodants this alloy is slightly superior to the pure metal. Moreover, although strength is in-

creased, ductility remains largely unaffected. Again, magnesium may be added to aluminium to give considerable accession of strength while maintaining corrosion resistance. When these alloys are cold worked as in rolling or drawing, high strength may be obtained, but this is naturally at the expense of some loss in ductility.

Where even greater strength is required, as in structural applications, the aluminium-magnesium-silicon heat-treatable alloys are available; their corrosion resistance is less than that of the binary alloys mentioned, but is nevertheless high. Under very aggressive conditions, structures in these alloys are painted, and very good paint lives have been reported.

Wrought pure aluminium and its alloys are available in all the usual semi-fabricated forms, namely sheet and strip, plate, bars, rods and solid and hollow sections, wire, forgings, tubes both drawn and extruded, and as rivets, bolts and screws. Forming and shaping of these products present no special difficulties.

### Aluminium castings

The above refers to wrought materials; castings are also important to the chemical engineer and are often made in pure aluminium to secure high durability. The pure metal is not easy to cast, and is rather weak; by selecting the right alloying element corrosion resistance of the same order as pure aluminium may be retained, while obtaining an alloy of good castability and mechanical properties. In general, the elements silicon or magnesium are most used and, by suitable combinations and heat treatment, sound castings with good machinability and high strength are available.

In view of the increasing application of low temperatures in chemical technology, aluminium and its alloys are particularly advantageous in having strength and ductility unaffected by sub-zero conditions; this applies to both wrought and cast materials.

All the commonly used alloys are covered by the relevant British Standards which are listed in Table 1, and the properties of the grades of pure aluminium and the most corrosion-resistant wrought alloys are the subject of Table 2, while Table 3 covers the most durable casting alloys.

The above are only very brief notes on the aluminium materials available; it was felt desirable to devote an appreciable portion of this article to recent developments which should be brought to the chemical engineer's notice.

### Super-purity aluminium

It may seem presumptuous to refer, in a chemical engineering journal, to super-purity aluminium as a relatively new material, since the unique properties of this material were first taken advantage of by the chemical engineer many years ago. However, it is only during the last few years that this metal has become available in large quantity at relatively low price and therefore some mention must be made of it.

The annealed material, which is available principally as sheet and wire, is almost leadlike in character, which is useful where extensive working is needed. Some accession of

**Table 1. British Standards for Commonly-Used Al Alloys**

B.S. 1490: 1955 'ALUMINIUM AND ALUMINIUM ALLOY INGOTS AND CASTINGS FOR GENERAL ENGINEERING PURPOSES"

*Wrought aluminium and aluminium alloys for general engineering purposes:*

| | |
|---|---|
| B.S. 1470: 1955 | Sheet and strip |
| B.S. 1471: 1955 | Drawn tube |
| B.S. 1472: 1955 | Forgings and forging stock |
| B.S. 1473: 1955 | Rivet, bolt and screw stock for forging |
| B.S. 1474: 1955 | Extruded round tube and hollow sections |
| B.S. 1475: 1955 | Wire |
| B.S. 1476: 1955 | Bars, rods and sections |
| B.S. 1477: 1955 | Plate |

**Table 2. Properties of Aluminium and the More Corrosion-Resistant Wrought Alloys**

(*All figures are minima unless otherwise stated*)

| *Type* | *B.S.* 1470 | 0.1% *Proof stress, tons/sq.in.* | *Tensile strength, tons/sq.in.* | *Elongation, % on 2 in.* |
|---|---|---|---|---|
| 99.99% Al | S1—O | — | 4.0 (max.) | 45 |
| | —H | — | 6.5 | 6 |
| 99.8% Al | S1A—O | — | 5.0 (max.) | 35 |
| | —H | — | 8.0 | 5 |
| 99.5% Al | S1B—O | — | 6.0 (max.) | 30 |
| | —H | — | 8.5 | 5 |
| 99% Al | S1C—O | — | 6.5 (max.) | 30 |
| | —H | — | 9.0 | 3 |
| Al-1¼ Mn | NS3—O | — | 7.5 (max.) | 30 |
| | —H | — | 11.5 | 3 |
| Al-2¼ Mg | NS4—O | — | 11.0 to 14.0 | 18 |
| | —½H | 12.0 | 15.0 | 5 |
| Al-3½ Mg | NS5—O | — | 14.0 | 18 |
| | —½H | 11.0 | 17.0 | 8 |
| Al-5 Mg | NS6—O | — | 17.0 | 18 |
| | —½H | 14.0 | 19.0 | 8 |
| Al-Mg-Si | HS30—W | 7.0 | 13.0 | 15 |
| | —WP | 16.0 | 19.0 | 8 |

*Symbols:* O = annealed, soft; H = hard; W = solution-treated; WP = fully heat-treated. Some of the above materials are also available in tempers other than those quoted. While the properties given are for sheet, those of other wrought forms are similar.

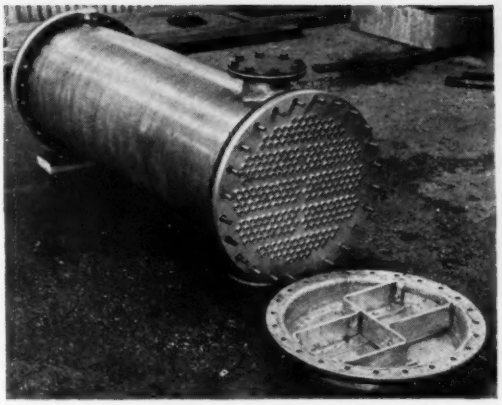
**Table 3. Specified Properties of Highly Corrosion-Resistant Cast Aluminium Alloys**

(*All figures are minima*)

| *Type* | *Designations (B.S.* 1490) | *Tensile strength, tons/sq.in.* | | *Elongation, % on 2 in.* | |
|---|---|---|---|---|---|
| | | *Sand cast* | *Chill cast* | *Sand cast* | *Chill cast* |
| Aluminium-5% magnesium .. | LM5—M | 9.0 | 11.0 | 3 | 5 |
| Aluminium-12% silicon .. .. | LM6—M | 10.5 | 12.0 | 5 | 7 |
| Aluminium-5% .. .. .. | LM8—M | 8.0 | 10.5 | 2 | 3 |
| Silicon-½% .. .. .. | LM8—W | 10.5 | 15.0 | 2.5 | 5 |
| | LM8—P | 9.5 | 12.0 | 1 | 2 |
| Magnesium .. .. .. | LM8—WP | 15.0 | 18.0 | — | 2 |
| Aluminium-10% magnesium .. | LM10—W | 18.0 | 20.0 | 8 | 12 |

M = as cast. W = solution-treated. P = precipitation treated. WP = fully heat treated

*Left:* **A large chemical container in aluminium plate.**
*Courtesy: A.P.V. Co. Ltd.*



*Right:* **Multi-pass condenser fabricated in 99.8%-purity aluminium.**
*Courtesy: British Aluminium Co. Ltd. and Burnett & Rolfe Ltd.*

strength is possible by using work-hardened material, but still the maximum strength obtainable is rather low. In order to maintain the exceptional corrosion resistance of this very pure metal, and yet to gain useful strength, recourse has been had to alloying with pure magnesium giving a work-hardening alloy, or with pure magnesium and pure silicon giving a heat-treatable alloy.

These 'super-purity base' alloys have been developed principally for non-chemical applications, but they deserve the attention of the designer of chemical equipment. Another fairly recent use of super-purity aluminium is as a cladding for aluminium alloy sheet and plate giving a composite material combining strength with very high surface durability. Even should the cladding be penetrated it will continue to serve as a sacrificial protection for the basis alloy.

## 'SAP'

The melting point of aluminium is relatively low and, as might be expected, its alloys offer rather low strengths at high temperatures; even those specially designed for high-temperature service which contain nickel as an alloying element are suitable only up to 300 to 350°C. A new material offering better high-temperature strength is made by powder metallurgy and, under the name *SAP* (sintered aluminium powder) is now available in this country in sheet, bar, sections, tubes and stampings. The high aluminium oxide content of this material, which is usually between 10 and 15%, confers the resistance to high temperature. Prolonged cycles of soaking at 500°C. do not affect the room temperature properties of the material. The corrosion resistance of *SAP* is similar to that of pure aluminium, and it may be anodised.

## Cladding developments

Most supply waters have little effect on aluminium when hot and some do not corrode the metal seriously even when cold. Certain waters, however, particularly those with an appreciable content of copper, can cause serious pitting of aluminium and its alloys in cold water if the water is static or slow moving. This is a considerable drawback in equipment such as tanks and heat exchangers, although with recirculatory systems the trouble can be avoided by the addition to the water of suitable inhibitors such as soluble chromates. This is not always practicable, and there is, therefore, much interest in the protection of tubes and sheet by cladding.

The cladding is so designed as to be slightly anodic to the basis material, and research in Britain and abroad has been mainly on an aluminium-1¼% manganese alloy clad with aluminium-1% zinc. Methods of manufacturing clad tubes have been developed and service trials are under way; indeed, in the U.S.A. general use of such material in contact with water is well in hand.

Aluminium sheet is particularly useful for cladding insulation on pipes, instead of the more conventional wire netting and felt. Two types of cladding are now commonly used, both in corrugated sheet; a thicker variety of about 22 S.W.G. is fastened by self-tapping screws, the other type being only 0.006-in. thick, and held in place by special aluminium straps and fasteners. In addition to simplicity of application these aluminium claddings, by virtue of their low emissivity, provide considerable additional insulation to the pipe. Ventilation ducting is increasingly being installed in aluminium; its high corrosion resistance eliminates the need for paint protection, and the supporting structures need only be light. The ready formability of the sheet simplifies the manufacture of ducting and bends.

## New joining methods

Although long the Achilles' heel of aluminium technology, joining is now readily accomplished by a variety of methods, principally due to post-war research. Clearly the most important development has been the inert-gas-shielded-electric-arc method of welding, and the two principal branches of this method can both be seen to have their fields of application. They are the inert-gas-shielded-tungsten-arc method where the arc is struck between a tungsten or tungsten alloy electrode and the work piece, and the inert-gas-shielded-metal-arc process where continuously fed aluminium or aluminium alloy filler rod forms one electrode.

In both cases the arc area is surrounded by a shroud of pure argon gas which prevents the reformation of the oxide film, and so permits welding without flux. Both these methods are suitable for hand or machine use and very high rates of welding may be attained and extremely sound welds with high weld strength efficiencies.

Moreover, the surface quality of the weld is high and for many applications may be used without further treatment; where necessary, the weld may be machined or mechanically worked to give a smoother surface.

With these rapid methods of welding the heat-affected zone in the parent metal is very narrow, and this is particularly advantageous where heat-treated or work-hardened materials are concerned, as these tend to be annealed by the welding heat. Much technical detail regarding these welding processes is now available and is published in such documents as the A.D.A. Information Bulletin No. 19.

Where its strength is sufficient, and

the temperature of joining must be kept as low as possible and distortion at a minimum, a brazed joint may be particularly useful. This involves an aluminium-silicon filler and the use of a corrosive flux, the residues from which must be thoroughly removed. Both welding and brazing may be used to join wrought materials or wrought forms to castings, which is often important in chemical plant for the attachment of cocks, valves, flanges, etc.

Some reference must be made to the new hard-soldering techniques involving zinc-base solders. It is claimed that joints made with these solders are highly corrosion resistant and tests are in progress to establish long-term durability.

Although of more interest in structures than in vessels, reference is necessary to the post-war research on large rivets in aluminium alloys, as a result of which it is now possible readily to drive, in the field, rivets up to 1 in. in diameter.

A very recent development concerned with joining is a process known as 'roll bonding.' Two sheets of aluminium are rolled together, producing pressure welding. A portion of the area between them is treated with 'stop off' so that it does not weld and subsequently, by the application of compressed air, this portion is inflated. This is a simple and cheap method of making a heat exchanger and is already finding extensive use in evaporators for refrigeration equipment. Other applications will present themselves to chemical engineers engaged in the design of equipment.

### Protective finishes

Anodising, as a means of improving the corrosion resistance conferred by the naturally occurring oxide film, is well established, but a variant of this is relatively new. By changing the anodising conditions, principally in the direction of high current density and refrigeration of electrolyte, hard and thick anodic coatings can be produced which give very effective protection against abrasion. On pure aluminium coatings, hardnesses as high as 500 V.P.N. are obtainable and abrasion tests show wear resistance comparable with that of cyanide case-hardened steel. It is suggested that designers consider such coatings for relevant portions of chemical plant.

### Chemical works structures

Quite apart from the apparatus involved in chemical manufacture, the aggressive atmosphere of chemical works presents considerable problems to the engineer responsible for the design and maintenance of buildings and structures. Over the past few years the use of aluminium alloys for structures in chemical works has extended, notably where the presence of sulphurous compounds in the atmosphere results in rapid attack of other structural materials. Aluminium alloy roofs and sidings are giving very good service, for instance, in gas works. Bare aluminium roofing sheet was shown in one very large chemical works to have a life approaching four times that of galvanised sheet. It is particularly noteworthy that, in areas where steel is found to require repainting at least once a year, painted structural aluminium alloys showed little deterioration after four years; this establishes the excellence of aluminium as a base for paint.

Aluminium may be a most useful protective coating for steel. Thus, sprayed aluminium on structural steel is well established and gives very good life, particularly if combined with paint treatment. Hot-dip aluminising is, however, quite new in the United Kingdom and only recently has any industrial application of it been made. An aluminium-silicon alloy is often used; the value of the silicon content is that it minimises the extent of the alloy layer at the junction of the two metals, and also renders it less brittle. The resistance to corrosion of hot-dip aluminised steel is excellent, particularly in polluted atmospheres. Recent investigations have shown that it has good scaling resistance at temperatures up to 800°C.

The above notes are only an indication of recent developments in aluminium and its alloys. It is claimed that the aluminium industry in Britain devotes a greater proportion of its effort to research and development than any other branch of the metal manufacturing trade. Therefore, it is in an excellent position to provide advice in the application of its products.

## Big Canadian Nickel Expansion

Confidence in the continuation of a big demand for nickel for industrial and military purposes, as well as in its geologist-explorers, was shown by the recent announcement by the International Nickel Co. of Canada Ltd. that it has made plans for the development over the next three or four years of a $175-million nickel project in the Mystery-Moak Lakes area of northern Manitoba.

International Nickel will open two new nickel mines in the area, to be known as the Thompson and the Moak mines. The project will constitute the biggest nickel-producing operation in the world next to Inco's operations in the Sudbury district of Ontario and will be the largest single investment of any kind in Manitoba. Together with the progress under way at Sudbury it will lift Inco's regular 1955 annual nickel-producing capacity by approximately 130 million lb. to 385 million lb., of which some 24 million will be regular production to replace existing temporary premium-priced production for the United States' national stockpile.

The Inco President, Mr. Henry S. Wingate, forecast on the basis of Inco's programme and the announced expansion plans of others, that total free world nickel capacity in some four years' time may be of the order 600 to 625 million lb., or an increase of about 175 to 200 million lb., from all sources above the total of 427 million lb. for 1955.

Simultaneously with the announcement of its new project Inco announced an increase in the price of nickel from December 6, and the Mond Nickel Co. Ltd., London, stated that from the same date it was raising the price for refined nickel in the U.K. to £600/ton delivered works, with appropriate increases for other countries.

---

### How to open a chemical plant

A novel use of a silver-plated oxy-acetylene blowpipe was involved in the official opening of British Oxygen's new liquid oxygen plant at Brinsworth, Yorks. The blowpipe was used to sever a thin metal strip which stretched between two models of air separation units. The parting of the metal strip completed an electric circuit, and the new liquid oxygen plant was set in motion.

The Brinsworth plant is one of six large new ones, which the company are installing in various parts of the country to meet the increased demand for gases from industry. It is part of a large industrial project at Brinsworth which will ultimately cost £2 million. The company plans to build an oxygen compressing station and a dissolved acetylene factory and may also, at a later date, erect a nitrous acid unit.

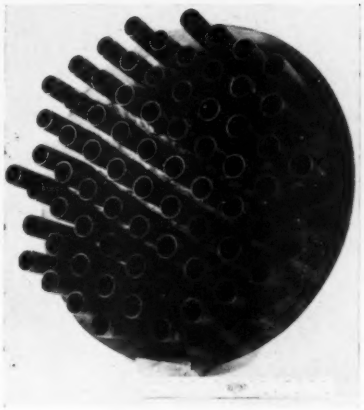
# New Chemical Engineering Uses for Titanium

TITANIUM is being increasingly used in aircraft, for gas-turbine compressor blades and discs, engine cowlings, exhaust shrouds and hot-air ducts where moderately elevated temperatures are met, and for other applications where erosive conditions are present. The metal has many other potential applications outside the aircraft industry, however, particularly in chemical engineering. These are still awaiting development —in the U.K. at least. Imperial Chemical Industries Ltd. is at present the only British industrial concern extracting the raw material, of which there is no shortage in the earth's crust, on a commercial scale. As the scale of production increases and the techniques of extraction and working are improved, it is expected that the present high price of titanium and its alloys will fall, but it is unlikely that this fall will be rapid.

It is interesting to note that some U.S. users, estimating the cost of corrosion equipment in 'cost per service year' claim already that titanium equipment is the least expensive for certain operations in terms of final cost.

Support for the idea of titanium as a useful chemical engineering material is indicated in reports from U.S. of the successful application of titanium in corrosive conditions in chemical plant. The complicated part for a chemical condenser illustrated, which is known as a 'top-hat insert,' was photographed after 14 months' service in a condenser handling vapours of 60% nitric acid at 300 p.s.i. and 195°C. There were no visible signs of corrosion at the end of this period, except for a slight discoloration. Its performance proved to be 2½ to 3 times better than stainless steel, the material previously used. This had failed from general attack within four to six months.

More recent news of the use of titanium in chemical processes is that engineers of the Wyandotte Chemicals Corp., Michigan, report great success during five months of trouble-free service with a large heat exchanger used to cool a 15% solution of sodium hypochlorite. Wyandotte engineers believe that titanium has solved what had been a major corrosion problem by its resistance to chloride ion attack. Other corrosion-resisting metals were found to be very much more expensive



Titanium 'top-hat.'

than titanium because of the very limited time of trouble-free service which they could offer before repair and replacement would be required. Glass and other non-metallic material were unsatisfactory because poor heat transfer prevented proper cooling, which resulted in the formation of chlorates detrimental to the process.

The cooler is a double-pass heat exchanger consisting of 48 tubes of 1-in. outside diam., 0.075-in. wall and 16 ft. long. Hypochlorite solution passes through the tube side; cooling water on the shell side. *Rem-Cru* A-55 was specified to resist chloride ion attack and the tubing was produced by Babcock & Wilcox Co., Pennsylvania, while Struthers-Wells Corp. designed and built the heat exchanger, which is believed to be the world's largest unit of this type produced in titanium.

*Some recent titanium developments are discussed in Mr. H. A. Holden's review of 'Metallurgy,' in this issue.*

---

**Industrial temperature-detecting** (B.S. 2765: 1956, 2s. 6d. net, 'Industrial temperature-detecting elements and pockets') aims at producing a uniformity of practice. It defines the terms relating to such elements and their protective devices and describes a dimensioning system, together with appropriate letter symbols, which may be employed in the preparation of purchasing specifications for industrial applications.

## RECENT PUBLICATIONS

**Automatic proportioning system.** A fully illustrated 32-page booklet from Henry Simon Ltd., of Cheadle Heath, Stockport, is devoted to the *Select-O-Weigh* automatic proportioning system originated by the Richardson Scale Co., of Clifton, New Jersey. It deals with many applications and aspects of the system and the notes are accompanied by illustrations of actual installations of the equipment.

Of particular interest is a demonstration of automation in an American rubber factory, where *Select-O-Weigh* equipment remotely controls the formulation of pelletised rubber, pigments, fillers, accelerators, carbon blacks and staining and non-staining oils.

**Carbon tetrachloride.** Carbon tetrachloride, $CCl_4$, is well established as an important member of the range of non-inflammable solvents, as well as being a widely used fire extinguishing medium. A new edition of a booklet on this chemical has been published by Albright & Wilson Ltd., 49 Park Lane, London, W.1. It reviews the chemical's principal applications, medicinal uses in particular, and also has notes on precautions in handling and the construction of plant in which carbon tetrachloride is used, as well as a table of physical data.

**Industrial eye accidents.** A pamphlet by Fleming Safety Goggles (division of J. & R. Fleming Ltd.) deals with the prevention of industrial eye accidents by the provision of suitable protective equipment.

**Fire protection.** Two publications of the Fire Protection Association, 15 Queen Street, London, E.C.4, deal with structural means of escape in buildings and with the fire hazard of static electricity, respectively. The first describes the principles governing the provision of fire separation and indicates the requirements for exits. The latter suggests methods by which static electricity may be dispersed or suppressed, and recommends precautions that can be taken in various processes, and in the handling of flammable liquids and dusts, to counteract the risks that arise.

**Laboratory presses.** Universal 10-ton laboratory presses for research control of production and process development are the subject of a pamphlet from Apex Construction Ltd., 15 Soho Square, London, W.1.

# Chemical Plant Parade in Paris

## IMPRESSIONS OF THE SALON DE LA CHIMIE

**Paris was recently the focussing point for a number of important technical meetings including the European Congress of Chemical Engineering and the European Congress of Corrosion, the 29th International Congress of Industrial Chemistry and other functions. Not the least important event at this time was the Fourth Salon de la Chimie, Caoutchouc, Matières Plastiques, at which a variety of chemical and allied plant was exhibited. Some impressions from the Salon are recorded here.**

*THE following is a brief summary of some of the exhibits; the headings are intended to provide only arbitrary divisions, not strict classifications, nor does the summary include more than a fraction of the total exhibits in these various fields.*

### SIZE REDUCTION AND MIXING

Among new items which attracted notice was the 3-in. multi-purpose mill displayed by Premier Colloid Mills Ltd., the Walton-on-Thames, Surrey, firm, who showed examples from their range of colloid mills and mixing equipment. While it can be said of the 3-in. unit that the degree of grinding and dispersion obtained makes it suitable for various purposes, it has proved itself especially useful in the paint field, as it can be used for the production of enamel paint of very high quality. Also featured on this stand were laboratory models of high-speed colloid mills for emulsion work and paste mills for dispersion work, together with portable and semi-portable mixing units for every type of agitation.

A laboratory turbo-agitator was an interesting item displayed by Rene & Jean Moritz, French associates of the Moritz Chemical Engineering Co. Ltd., London. The agitator is a small standard unit, a laboratory-scale version of a larger model that has already had considerable success on the industrial scale.

A hydraulically-controlled single-roll mill, used for the production of paints, enamels, printing inks and leather dressings, was featured by the French agents of Vickers-Armstrong (Engineers) Ltd.; this mill is fitted with a vane bar of unique design, to which hydraulic pressure is applied. The machine exhibited had a roll 16 in. in diameter by 26 in. long. Another feature of the stand was a toilet soap plodder used for the continuous production of a highly compressed and homogeneous bar when fed with milled toilet soap.

Along with apparatus and reagents for use in laboratories, Prolabo showed their *Dangoumau* grinding mill which, it is claimed, can speedily reduce a wide variety of materials, including minerals, coal, cement, seeds, leaves, etc. Grinding capacity is 1 to 20 g. The sample, completely enclosed in a tight receiver, is entirely recoverable.

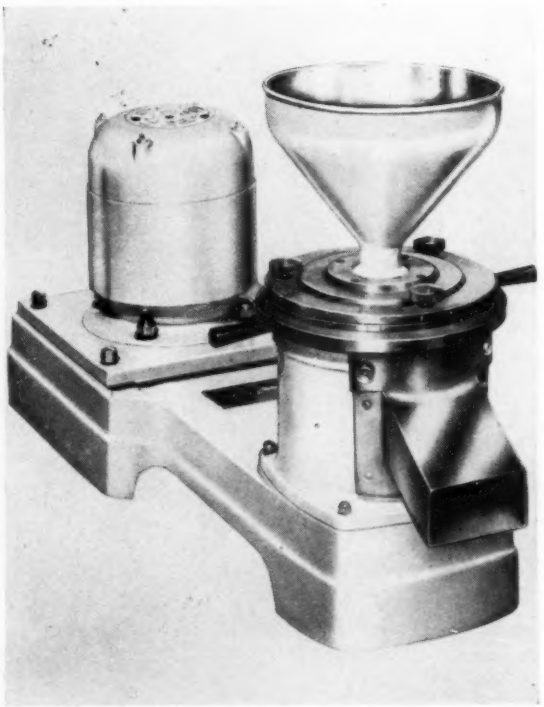
A reducer exhibited by Cidma can be used for mixing and agitating processes in the chemical and paint industries, as well as in laboratory work. Features include: a coaxial motor with slow-running shaft, gears made of Ni-Cr steel with rectified teeth, slow-running planetary gear, and satellites on bearings.

### MATERIALS OF CONSTRUCTION

While some fairly new materials appeared in the various items of chemical plant shown, there was no very obvious departure from the more conventional materials and variations of them.

The continued interest in plastics is exemplified by a centrifugal pump in PVC shown on the stand of Société Anisa, along with other items in polyvinyl and polyester materials and an absorption and neutralisation tower for acidic and nitrous vapours.

Corrosion prevention was the chief focus of the firm of S.E.P.I.A. Coatings of vinyl, epikote, polyester and neoprene were to be seen, along with anti-acid cements which are reported to be of good stability under severely



**Premier Colloid's latest mill.**

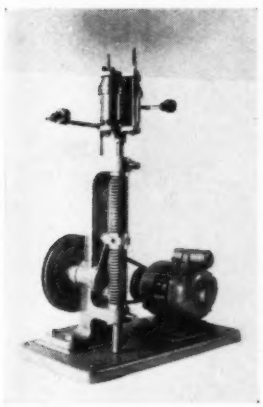
corrosive conditions. A ' first time ' exhibit was *Corrostop* slabs and bricks for construction work in corrosive conditions.

Performance under the effect of ozonising radiations, ultra-violet rays and atomic radiations, rather than resistance to corrosion, was emphasised by Quartz & Silice. In the infra-red field, apart from the heating of the stand by high-power units, this company put the accent on industrial applications of the *Infratube*, presenting a collection of photographs of drying ovens equipped with these heat generators.

Graphite and stoneware, as well as stainless-steel items, were shown by a number of firms, including Laguilharre, who exhibited vapour ejectors in all three materials, along with such items as a multiple-effect evaporator and stainless-steel centrifugal pumps.

Glass is a material which is becoming increasingly evident in chemical plant, and examples of glass-lined cast iron and steel plant for the chemical industry were shown, among others, by Danton-Rogeat. This company also offered, as a further proof of its versatility, stainless-steel plant, and also equipment lined with *Teflon*, *Hypalon* and *Rilsan* plastics.

Further examples of the combinations of materials that can be achieved were evident on the de Dietrich stand,

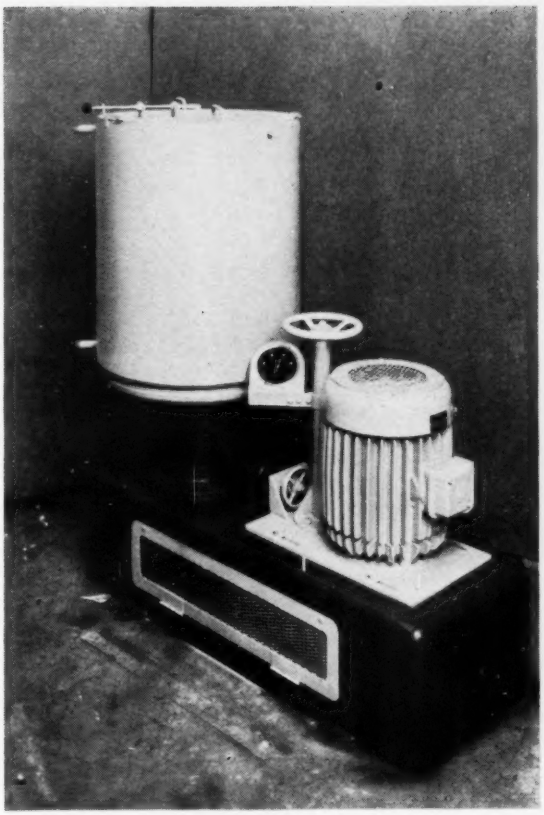


*Left:* **Prolabo's ' Dangoumau ' grinding mill.** *Right:* **Complete spray-drying unit exhibited by Niro.**

where glass-lined plant was accompanied by rubber-lined items, while prominently displayed was a vessel consisting of a tank in enamelled steel with its cover in enamelled cast iron. The company claims to be able to produce a rubber lining which will withstand satisfactorily a temperature of 266°F. during continuous working, giving complete protection against chemical attack. Special formulae have been developed allowing vulcanisation using hot water or hot air. This rubber lining can be applied on a very wide range of metal constructions.

Graphite heat exchangers of unusual design were shown by Société le Carbone-Lorraine, these units being assembled from graphite blocks which are held together under compression by external tie bars, bundle or tubular heat exchangers, coaxial tube exchangers, piping and water-coolant equipment.

Stainless-steel products and clad plates were featured as a speciality of the Stinox concern and various test samples and illustrations of heavy chemical and petroleum equipment, as well as Haynes *Stellite* hard-facing alloys, were on view.

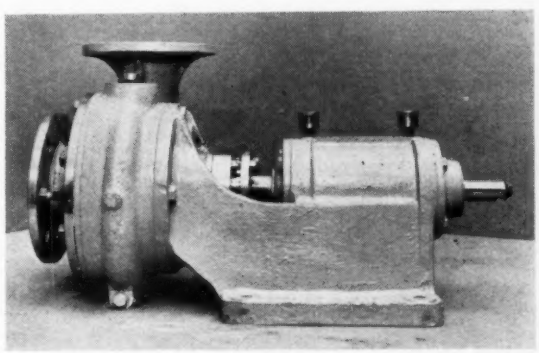


**Turbo-agitator by Moritz.**

Titanium made an appearance on the stand of the Ugine concern, which showed a series of parts made of titanium or titanium alloys, in the form of ingots, bars, sections, sheet and sponge. Zirconium parts and stainless-steel sheet were among other items here.

### SEPARATION PROCESSES

British contributions in this sphere included a 100-tube, fully automatic, counter-current, liquid/liquid extraction machine, a counterpart of the largest laboratory glassware unit made by Quickfit & Quartz Ltd., which formed the centrepiece of this company's display on the stand of its



**Centrifugal pump for industrial use, shown by Les Pompes R. Lefi S.A.**

French distributors, Société Canal. Also on exhibition was a circulatory cyclone evaporator which is being used by a Slough firm in the preparation of chemicals worth thousands of pounds.

A separation technique of a very different sort was featured by Chamberland Système Pasteur, with their range of pressure and non-pressure filters which incorporate candles made of porous porcelain. These are used for sterilisation and micro-filtration.

Coming into the open-air site of the exhibition, one found items such as the nitric acid absorption tower, shown by la Soudure Autogène, along with various other items of chemical plant in stainless steel.

Centrifugal separators for laboratory and industrial purposes, built by the German company Westfalia Separator A.G., were exhibited by S.E.S.I. These covered a considerable range of separation operations; continuous separation of two liquid phases, and also removal of solids dispersed therein; clarification of liquids with small percentage of solids; continuous de-sludging of liquids with a high percentage of solids; mixing of two liquid phases; and counter-current liquid/liquid extraction.

The outstanding feature of the Niro stand was a complete standard spray-drying unit with an evaporating capacity of 10 to 20 kg. (22 to 44 lb.)/hr. according to the temperature admitted by the product. This apparatus is used in large research laboratories and is likewise available for small-scale production.

Moritz displayed a scale model of a reaction tower which has been designed chiefly for the production of sulphuric acid by contact. Its basic interest lies in the fact that it permits of accelerated elimination of the calories produced by the reaction. It may be further used to cover all problems of gas absorption.

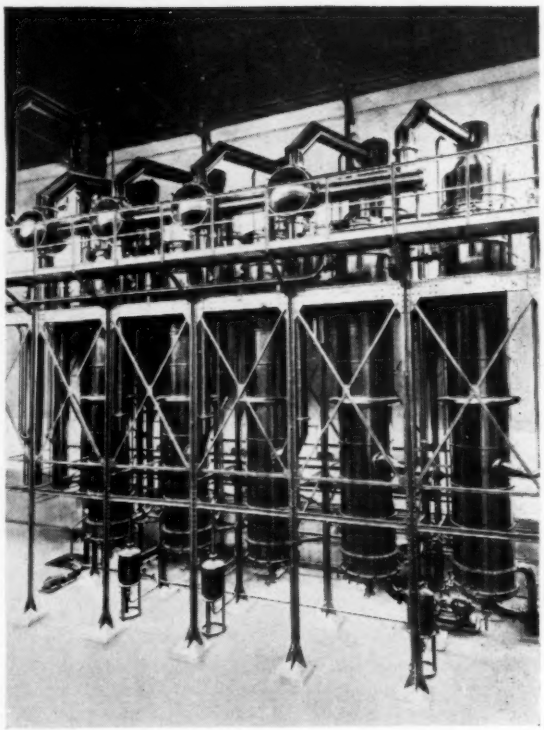
Filters ranged from such items as cartridge units, shown by Cuno Engineering, for the filtering of paints, etc., to the leaf filters with special cleaning facilities shown by Hercules (U.S.). This company's SLF type is self-cleaning, cakes being removed in less than 3 min. by pressurised sprays while the filtering leaves continue to rotate.

### CHEMICALS

The great range of Canada's still-expanding chemical industries were indicated by a display sponsored by the Canadian Department of Trade and Commerce, and comprising individual displays of 20 Canadian companies manufacturing general chemicals.

A British company who can always be relied upon to produce something interesting is Imperial Chemical Industries, who made a feature of their range of rubber chemicals, in particular *Vulcacel*, *Vulcafor* and *Nonox*. Samples of coloured rubber and PVC illustrated the wide range of high-quality colouring matters manufactured by the Dyestuffs Division.

Another British exhibitor, Johnson, Matthey & Co. Ltd., showed, as a recent development, a new and brighter range of cadmium pigments. The increased brilliance of these materials was shown in examples of the use of these



*Top:* **Chemical vessels on the de Dietrich stand.**

*Middle:* **Multiple-effect evaporator by Ets. Laguilharre.**

*Bottom:* **Components of a small model 'Polybloc' heat exchanger shown by Société le Carbone-Lorraine.**

pigments in plastics, rubber and paint, while test specimens demonstrated their stability. For the chemical industry the company are large producers of equipment and catalysts in the noble metals. Several examples of plant and of catalytic materials of different forms were on display. In addition, an extremely wide range of chemical products was shown, including spectrographically standardised substances of the highest purity, rarer elements and compounds, salts of the precious metals and rare earths. The extraction and purification of the latter has been one of the company's research projects for some time, and today all 15 known rare earths are produced in a state of high purity. Standard Johnson, Matthey platinum apparatus for chemical and electro-chemical analysis was also displayed.

The remarkable properties of silicones, such as stability under prolonged effect of atmospheric agents, inertia against oxidising products and resistance to high temperatures, were emphasised in a selection from the silicones manufactured by the Rhone-Poulenc organisation, while Ugine demonstrated the utilisation of chlorofluoric hydrocarbons as propellents in aerosols and as refrigerating liquids, as well as the uses of sodium chloride.

### INSTRUMENTS AND CONTROLS, TESTING APPARATUS, ETC.

Current trends in instrumentation and automatic control could be seen by the study of a number of items, such as the indicating and recording pressure gauges, shown by Bourdon (including differential pressure gauges, pneumatic indicating receiver gauges, pulsation dampeners, etc.), and remote control equipment (including synchros, level indicators, manometers and other equipment) shown by Saint-Chamond-Granat. The newer departures were indicated by, for instance, an industrial television unit shown by Thomson-Houston and comprising platform- and turret-type cameras. Pictures are taken continuously and received on 18-, 36- and 54-cm. (7-, 14- and 21¼-in.) receivers.

The Compagnie Française Thomson-Houston showed electronic equipment, including a mass-spectrograph for qualitative and quantitative analysis, and a thermal conductivity cell for the analysis of combustible gases, exhausts, detonating mixtures, control of furnace atmospheres, control of the hygrometric degree of the air, and of use in isotope analysis in gaseous chromatography and in the study of diffusion, catalysing and adsorption processes.

Microscopes were featured on the stand of Barbier, Benard & Turenne, who showed a range of new optical instruments for use in industry and medicine.

A universal microscope included all current techniques of magnifying and could be used for examining fine biological specimens as well as samples up to 8-cm. thick. A recent addition to this model is polarisation equipment, consisting of a monocular head with a drawtube and Bertrand lens and an object glass. Another exhibit here was a polarising microscope (A) equipped with a centering plate and allowing extra slides to be inserted. The lens can be adjusted or withdrawn.

### METAL TREATMENT, ETC.

Moritz showed their range of electronic induction-heating generators, with 800-w., 2.5-kw., 7- to 8-kw., 30-kw. and 100-kw. models. These units, made in France under British Redifon licence, make it possible to obtain very interesting results in the thermal treatment of metals, superficial and localised hardening, welding, brazing, annealing, smelting, de-gasifying, etc., from the point of view of both quality and speed.

Two interesting items on the stand of Pompes Celtiques were the *Pyrex* circuit and apparatus for measuring the hardness of metal alloys at temperatures up to 950°. The machine can be automatically controlled when the duration is less than 100 sec. or manually when a duration under load of more than 100 sec. is concerned.

---

## Equilibrium between Nitrogen Dioxide and Nitrose

According to Russian workers, the equilibrium between $NO_2$ and nitrose (nitrosic sulphuric acid as it is referred to) has been insufficiently studied, although of considerable practical and theoretical interest. It is pointed out that most of the published work on the equilibrium pressure of nitrogen oxides with nitroses in the presence of nitric acid has been based on blowing nitrogen through nitrose (solution of nitrosyl-sulphuric acid in sulphuric acid), with subsequent absorption of the nitrogen oxides by sulphuric acid. Usually only a narrow range of nitrosivity and sulphuric acid concentration has been used.

Thus, in earlier Soviet work referred to, the vapour tension of nitrogen oxides was determined over nitrose of initial acid concentration of 90% $H_2SO_4$, containing 0.5 to 6% $N_2O_3$ and 0.4% $HNO_3$; or with initial acid concentration of 75.6%, with 0.5 to 2% $N_2O_3$ and 0.07 to 0.08% $HNO_3$. Another noted the effect of even small amounts of free nitric acid on desorption rate of nitrogen oxides, using nitrose of 70.85% acid strength with 3.6% $N_2O_3$ and 0 to 0.8% $HNO_3$, and another with up to 11% nitric. Various other experiments with different-strength nitroses are noted. The results reported are to some extent contradictory.

The present work aims to study the equilibrium between a gas containing $NO_2$ and the liquid phase through absorption of $NO_2$ by sulphuric acid of concentration ranging from 0.0 to 98.0% with constant partial pressure of $NO_2$ in the gas. (See I. E. Ioshpa *et al.*, *Zh. prikladn. Khim.*, 1956 (6), 862-870.)

## GREETINGS

*A number of companies, organisations and individuals have sent us seasonal expressions of goodwill in the form of gifts, diaries, calendars and cards, and we offer hearty reciprocal greetings to all. Particular thanks are due to Albright & Wilson Ltd., Aluminium Development Association, John Benington Ltd., Brazier & Partners, British Filters Ltd., F. & D. Brownlie, The Distillers Co. Ltd., Edwards High Vacuum Ltd., Globe News Service Ltd., W. J. Jenkins & Co. Ltd., Marchon Products Ltd., National Industrial Fuel Efficiency Service, Pfizer Ltd., Pyrene Co. Ltd., Sidney-Barton Ltd., Taylor Woodrow (Building Exports) Ltd., Tibbenham Publicity Ltd., Webster Ridgway & Partners Ltd., Widnes Foundry & Engineering Co. Ltd., Henry Wiggin & Co. Ltd., and Zinc Development Association.*

# Hazards in Handling Pentachlorophenol

*By H. Allen*

WITH new chemicals coming rapidly into industrial and agricultural use, and with chemical compounds increasingly applied for production purposes in modern industry, there is the constant need to keep safety precautions in step with applications and, on the basis of empiric findings, to formulate codes of practice that will safeguard operator health.

Pentachlorophenol, for instance, the powerful fungicide and bactericide, is now in wide use in preservative processes in a comprehensive variety of trades such as timber, glues, hemp, jute, furniture, textiles, leather, lacquer and paint, and so on. That its hazards should be known and that safe working codes concerning it should be detailed are therefore of obvious importance.

Produced either by the direct catalysed chlorination of phenol (as a bactericide it is 50 times more potent than phenol), or by the reaction between sodium hydroxide and hexachlorobenzene, pentachloride is almost insoluble in water but readily soluble in benzene, ether, alcohols and in some light mineral oils. A solid substance, it forms white crystalline flakes and has a density of 1.98. Its vapour pressure is low ($1.7 \times 10^{-4}$ mm. Hg, 20°C.) and it is chemically stable in water.

Its hazards are not serious, but it is toxic in a moderate degree to human beings and has high toxicity to animals. Furthermore, it can be a severe irritant. Fumes from heated PCP or dusts arising from it cause coughing, inflammation of the respiratory tract if exposure is prolonged, running of the eyes, sneezing and general discomfort.

As PCP has no pharmaceutical uses, little research data has been collated to illuminate fully the degree of toxicity to human beings, but, since industry began to use it widely and diversely, much empiric material has come to light and the many occasions when there has been accidental overexposure to PCP have shown the reactions that are set up and have indicated on what points a code of safe working must be hinged.

## Occupational hazards

Post-accident investigation of overexposure has clearly shown that respiratory conditions are affected by fumes and dust and there may be a time lag before they become manifest. The chest, nose and throat irritations which are set up, however, have so far been proved temporary and there is no evidence, to date, that permanent ill effects are caused.

Secondly, there is an effect on the skin. PCP is fairly readily absorbed through the skin. Tests on animals have proved that it produces severe skin reactions after external applications of solutions or dusts. Concentrations over 1% PCP in solvents or in inert dusts produce severe inflammation and structural skin changes. Solvents heighten both absorption and skin reaction. With human beings, concentrated solutions over 10% can cause skin changes. Prolonged low-grade contamination of the skin with PCP causes a form of dermatitis in which the skin reddens, swells, develops boils and spots, thickens and becomes pigmented. The effect, which is persistent, is nevertheless confined to the external skin. But it may cause scarring, is disfiguring and unpleasant.

The third effect is potential neurological disturbance. Experiments with animals have shown that poison from PCP causes tremors, convulsions, nerve cell injury and injury to the nervous system. If there is internal absorption of PCP with human beings, affected employees may complain of numbness in limbs, ' pins and needles ' in hands and toes, cramp, weakness of grasp and so on. There may be leg pains and again the effects, though persistent for some time, eventually clear without any permanent harm. So far, all observation has shown that there is no change in blood cells or biochemistry.

## Safety code

So much for the occupational risks. The safe working code that follows can be simply enunciated. First the maximal allowable concentration, the basis of most chemical safety codes: with PCP it is generally accepted, for factories, as 0.5 p.p.m. Standard practice is the analytical method for the determination of PCP in biological materials or in water, based on the spectrophotometric measurement of the reddish pigment produced by the reaction between PCP and fuming nitric acid.

The first safety rule with PCP is that precautions must be taken to prevent contamination of the skin from splash or spray. With both concentrated and diluted material the use of protective wear is essential. Rubber gloves and boots and faceshields will play their part. Careful handling (and that means training of operatives in the technique of handling) will do much to reduce the splash hazard. Training of workers should include instruction in the first-aid measures to be employed when contamination occurs. The skin should immediately be thoroughly washed with soap and water. Skin cleanliness generally is important. If any clothing becomes contaminated with PCP it must not be allowed to remain in contact with the skin. Protective uniform will obviously reduce this hazard.

Although the internal absorption of PCP is not a common hazard, it must be appreciated that it may exist. Operators must be trained to avoid inhalation of spray mist during processing and, where some degree of exposure is inevitable, face shields or respirators should be worn. There should be scrupulous care to ensure that there is no accidental contamination of drinking vessels or of other personal equipment.

Broadly speaking, it would seem at present that, with PCP, its worst potential hazard is that of severe skin irritation which can be prevented by a safe working technique; toxicity is moderate and only marked overabsorption will have seriously damaging effects.

Incidentally, the toxicity of the sodium salt (Na PCP) is the same as that of PCP itself.

---

**Nylon ropes** are the subject of a 20-page booklet published by British Nylon Spinners Ltd. It contains a summary of the properties such as tensile strength, shock resistance and flexibility, making nylon suitable for ropes, but the greater part is devoted to factual reports of instances in which nylon has reduced costs, eased handling problems or increased efficiency.

# The C.P.E. COST INDEX for the Construction of Chemical Plant

## *A New Service for Our Readers*

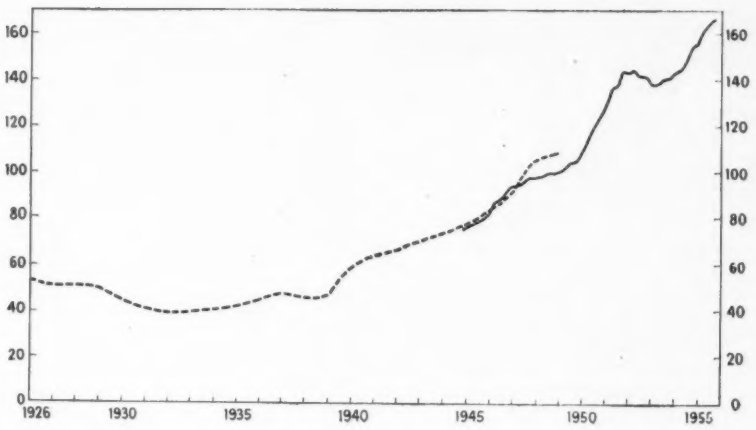
CHEMICAL engineers in Britain have need of an index by which they can compare capital costs in different years. This is particularly true for those concerned with estimating and with process development. During a period of economic inflation, as at present, such an index has added interest and significance.

As a service to its readers, CHEMICAL & PROCESS ENGINEERING proposes to publish each month an index for conditions in Britain over the last few years. Each month a new figure will be added to the index.

Table 1 shows our index figures month by month from January 1945 to October 1956. The Board of Trade indices of wholesale prices and the Ministry of Labour index of wage rates (adjusted to same base in June 1949) form the basis of the new index. In compiling this the weightings used are:

| Materials used in: | % |
|---|---|
| Mechanical engineering ... ... | 50 |
| Electrical engineering ... ... | 10 |
| Building and civil engineering ... | 20 |
| Wage rates ... ... ... ... | 20 |

The only prior publication of this nature is the index printed in the Association of British Chemical Manufacturers' 'Report on Chemical Industry,' 1949. This index is based on June 1937. In Table 2, for purposes of comparison, we have recalculated the A.B.C.M. index to the same base, June 1949, as our own index.




In the accompanying graph, both indices to the same base are plotted against time. The A.B.C.M. index is shown as a broken line, while the new C.P.E. index curve is shown in full. It will be noticed that the two curves coincide in 1945, 1946 and 1947, but diverge in 1948 and 1949.

**The curves show how British chemical plant costs have soared in the past few years. Next month, British and American costs will be compared.**

**Table 2. A.B.C.M. Cost Index for Construction of Chemical Plants**

(June 1949 = 100)

| Year | Index | Year | Index | Year | Index | Year | Index | Year | Index |
|---|---|---|---|---|---|---|---|---|---|
| 1926 | 53.5 | 1931 | 41.2 | 1936 | 44.0 | 1941 | 64.2 | 1946 | 82.7 |
| 1927 | 50.8 | 1932 | 39.0 | 1937 | 47.2 | 1942 | 66.5 | 1947 | 92.0 |
| 1928 | 50.4 | 1933 | 39.4 | 1938 | 45.8 | 1943 | 70.5 | 1948 | 105.6 |
| 1929 | 49.5 | 1934 | 40.3 | 1939 | 46.7 | 1944 | 73.4 | 1949 | 108.2 |
| 1930 | 44.8 | 1935 | 41.2 | 1940 | 58.2 | 1945 | 77.2 | | |

**Table 1. Chemical Plant Construction Cost Index**

(June 1949 = 100)

| | 1945 | 1946 | 1947 | 1948 | 1949 | 1950 | 1951 | 1952 | 1953 | 1954 | 1955 | 1956 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Jan. | 75.0 | 80.6 | 90.3 | 97.7 | 99.9 | 104.3 | 121.4 | 137.6 | 141.3 | 140.7 | 150.4 | 164.4 |
| Feb. | 75.4 | 80.7 | 91.1 | 98.0 | 99.7 | 104.5 | 121.4 | 137.9 | 141.2 | 140.1 | 154.3 | 164.4 |
| March | 75.2 | 80.9 | 92.1 | 98.0 | 99.4 | 104.6 | 123.4 | 143.5 | 141.0 | 140.6 | 154.9 | 166.5 |
| April | 75.8 | 82.0 | 93.5 | 98.0 | 102.0 | 105.1 | 126.2 | 143.9 | 139.6 | 141.5 | 155.3 | 165.9 |
| May | 76.0 | 83.3 | 93.9 | 98.2 | 101.2 | 107.3 | 127.3 | 143.0 | 137.6 | 142.9 | 154.2 | 166.1 |
| June | 76.9 | 83.5 | 93.8 | 97.9 | 100.0 | 109.3 | 128.1 | 143.0 | 137.5 | 143.8 | 155.1 | 164.9 |
| July | 77.2 | 85.2 | 94.1 | 97.9 | 99.3 | 110.8 | 129.0 | 144.0 | 138.7 | 143.8 | 156.7 | 164.9 |
| Aug. | 77.6 | 85.5 | 94.3 | 97.6 | 99.7 | 112.3 | 132.8 | 143.3 | 137.7 | 143.6 | 161.5 | 165.3 |
| Sept. | 77.8 | 86.4 | 94.5 | 97.7 | 101.1 | 114.4 | 136.1 | 143.1 | 137.8 | 144.6 | 163.1 | 165.8 |
| Oct. | 77.9 | 86.7 | 96.0 | 99.2 | 103.9 | 115.8 | 136.1 | 142.1 | 139.0 | 146.8 | 161.6 | 166.3 |
| Nov. | 78.2 | 87.3 | 97.0 | 99.4 | 104.4 | 118.5 | 135.9 | 140.1 | 140.6 | 146.9 | 162.8 | |
| Dec. | 78.6 | 88.0 | 96.9 | 99.6 | 104.1 | 120.1 | 136.7 | 141.4 | 140.8 | 147.8 | 159.0 | |
| Aver. | 76.8 | 84.2 | 94.0 | 98.3 | 101.2 | 110.6 | 129.5 | 141.9 | 139.4 | 143.6 | 157.4 | |

# New Books

## Electrostatic precipitators

In the preface to this book* the authors point out that, although the electrostatic precipitator is widely used and a very high standard of performance is achieved, an examination of the literature relating to the subject shows that the basic theory is, at present, unsatisfactory, that many of the phenomena encountered are imperfectly understood, and that present designs are based mainly on empirical data which have been accumulated by the various manufacturers. The principal object of this monograph, therefore, is to bring together and analyse the available information on the subject, though the authors' own opinions are expressed and their own research experience quoted. Though the book opens with a study of the theoretical aspects of its subject, later chapters consider problems of design, construction and efficiency from a practical point of view.

**An Introduction to Electrostatic Precipitation in Theory and Practice*, by H. E. Rose and A. J. Wood. Constable & Co. Ltd., London, 1956. Pp. 166, inc. index. Illus. 17s. 6d. net.

## Hydrogen ions

Hydrogen-ion concentration measurements constitute an invaluable means of investigating and controlling chemical reactions and the publication of this standard work in a revised and up-to-date edition* will be welcomed by technical chemists and students. While the first volume dealt mainly with the theory and methods of determining hydrogen-ion concentration or activity, this second volume examines the part played by hydrogen ions in chemistry and its numerous technical processes in industry. A section deals with the application of electrometric methods for the titration of acids and bases in non-aqueous media.

**Hydrogen Ions*, by Hubert T. S. Britton. Fourth edition. Chapman & Hall Ltd., London, 1956. Pp. 489, inc. index. 75s. net.

## Oil-firing equipment

The whole field of oil firing both for domestic and industrial heating applications is covered from an essentially practical point of view in this book.* It is directed particularly at those, such as heating engineers, architects and plant engineers, who are concerned with the installation and maintenance of oil-firing equipment, and it is intended to become a work of reference which might be revised and brought up to date periodically.

**Oil Fuel Applications*, by A. T. Henley. Crosby Lockwood & Son Ltd., London, 1956. Pp. 250, inc. index. Illus. 35s. net.

## Chemical analysis

For the 11th edition of this work* by Cumming and Kay, first published in 1913, a considerable amount of revision has been introduced. Among the chief alterations are the rewriting of the section on colorimetry and the writing of a brief account of the theory of precipitation and contamination of precipitates. Short lists of suggested reading matter are included and an appendix lists common reagents, solutions for analysis, typical analyses and specific gravities of reagents.

**Quantitative Chemical Analysis*, revised by R. A. Chalmers. Eleventh edition. Oliver & Boyd Ltd., Edinburgh, 1956. Pp. 540, inc. index. Illus. 30s. net.

## Chemical-resistant materials

The sixth issue of the *Dechema-Werkstoff-Tabelle*, dealing with the chemical resistance of materials of construction to aggressive media, ' Chlorwasserstoff ' to ' Diglycolsäure,' edited by H. Bretschneider and E. Rabald, has now been published.* This brings up to 600 pages the completed portion of the standard work, which it is anticipated will ultimately consist of more than 1,000 separate sheets and will represent a summary of the knowledge and experience gained during the last 25 years in the briefest form.

The latest issue includes 12 sheets with further important information and notes regarding the behaviour of constructional materials towards hydrogen chloride and hydrochloric acid. A comprehensive review is given of all available information on these aggressive media in regard to their effect on metals, non-metallic inorganic substances and organic materials. The present issue also contains a large number of other sheets, including some of particular interest, such as detailed reports on the resistance of materials of construction to chromic acid, chromium trioxide, citric acid, DDT and diazo compounds.

**Dechema-Werkstoff-Tabelle.* Dechema, Frankfurt/Main, 1956. Sixth issue. Pp. 100.


**TECHNICAL BOOKSHOP**

*All books reviewed in* CHEMICAL & PROCESS ENGINEERING *and any other scientific or technical book may be obtained from:*

*The Technical Bookshop,*
308 *Euston Road,*
*London, N.W.*1
(*Telephone: Euston* 5911)

*Prompt attention will be given to all orders.*


## Friction and lubrication

Based largely on researches carried out by the authors and their colleagues at Cambridge, this monograph* on the subject of friction and lubrication has been kept simple and non-mathematical in treatment.

The opening chapters present the historical background to the study of friction and introduce the knowledge necessary for the understanding of the basic frictional mechanism. The general physical model developed is concerned primarily with metals, but non-metals are dealt with later and it is shown that the mechanism of friction is in many ways similar, although there are important differences.

The second part of the book deals with the behaviour of lubricated surfaces and again provides a historical survey of work on the subject, while attention is also paid to recent studies in this field. In these chapters some reference is made to recently developed synthetic lubricants.

**Friction and Lubrication*, by F. P. Bowden and D. Tabor. Methuen & Co. Ltd., London, 1956. Pp. 150, inc. index. Illus. 10s. 6d. net.

## Calenders in the rubber industry

This monograph* on calenders is one of a series which is being sponsored by the Council of the I.R.I. After a historical introduction, calender design in general is reviewed; different types of calender are considered in detail and ancillary equipment, such as driving gear, rubber feeds, reel-off and batch-up gear, is also examined. A chapter is devoted to roll contours and the study ends with a review of the uses of calenders in production.

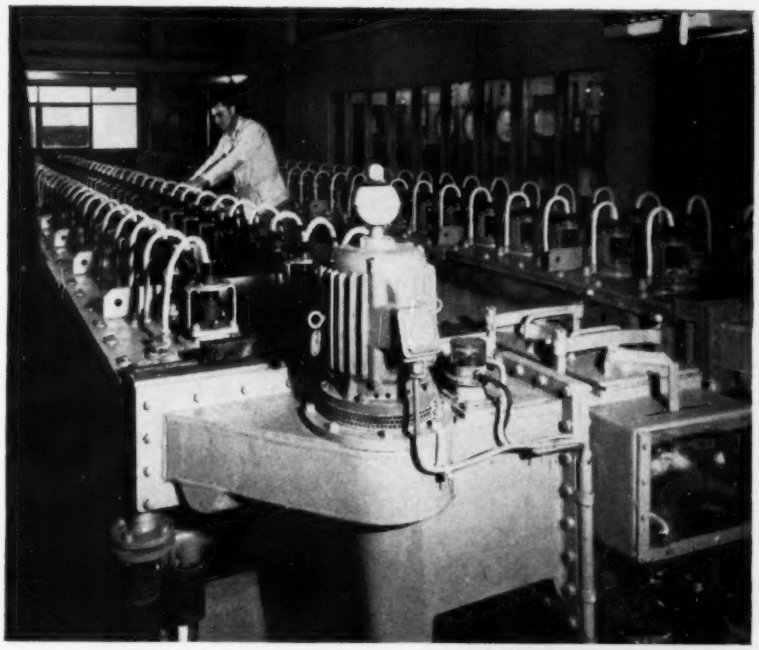
**Calenders for Rubber Processing*, by H. Willshaw. Institution of the Rubber Industry, London, 1956. Pp. 61, inc. index. Illus. 25s. net.

# Economical Production of Chlorine

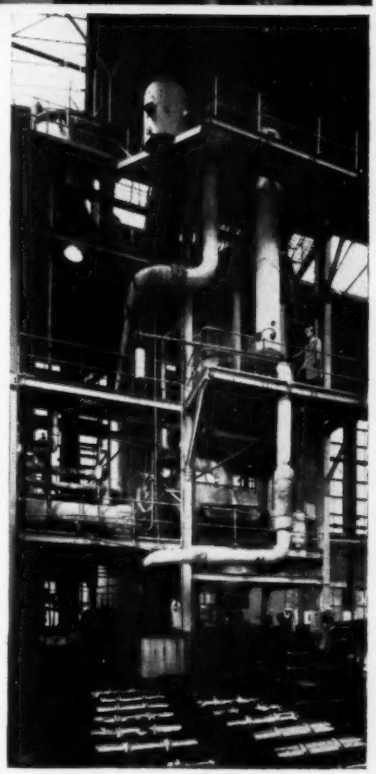
## BY-PRODUCT UTILISATION A FEATURE OF BIG NEW PLANT

*EXPANSIONS, costing £1,600,000, recently completed at the Elworth, Cheshire, works of the Murgatroyd Salt & Chemical Co. Ltd., more than double the output of chlorine and caustic and produce as a new product a very pure grade of caustic soda. The new installation makes use of an advanced type of Uhde mercury cell for the electrolysis of brine, instead of Hooker diaphragm cells as previously installed.*

*Interesting features of the plant include the ingenious utilisation of by-products: thus, by-product salt from the Hooker diaphragm cells previously installed is used up in the new mercury cells, while hydrogen from the Hooker cell room is burnt in the boiler installation serving the plant.*



*Above:* **End view of a mercury cell showing the pump with its signal bob.**



*Right:* **Anhydrous caustic plant, with filled drums in the foreground waiting for export.**

### The background

Murgatroyd's are now under the joint control of the Distillers Co. Ltd. and Fisons Ltd., and the significance of the new installation lies in the fact that the increased amounts of chlorine now available match up with the Distillers' expanded production of polyvinyl chloride at Barry, Glamorgan, while at the same time Fisons, for their chemical and pharmaceutical interests, will now get rayon-grade caustic soda from the mercury cell installation, as well as ordinary grade from the diaphragm cells.

It was in 1947 that Murgatroyd's began construction of a new works at Elworth, three miles south of their old open-pan salt plant, to make salt in modern triple-effect evaporators and, in addition, to produce chlorine, caustic soda, hydrochloric acid and sodium hypochlorite by methods based on the electrolysis of purified brine. This plant was commissioned in 1950. The new expansions were begun in 1954.

### General processes

Sodium chloride solution (brine), purified by chemical treatment and brought to a suitable concentration, is filtered and stored in header tanks, from which it is fed by gravity to the new batteries of Uhde mercury cells.

In the first (electrolyser) section of each cell, electricity flows through the brine from a graphite anode to a cathode which consists of a flowing stream of mercury. Chlorine gas is liberated at the anode; sodium is liberated at the cathode, and forms a liquid amalgam with the mercury. The amalgam flows into the second ('decomposer') section of the cell, where it reacts with water to form hydrogen gas and a solution of sodium hydroxide. The spent brine from the electrolyser is dechlorinated, more salt is dissolved in it, and the cycle of operations repeats continuously.

The chlorine is collected, dried by means of sulphuric acid, and is liquefied under pressure at 5°C. The hydrogen is used as a fuel gas. The sodium hydroxide solution is evaporated to yield solid caustic soda.

In the earlier (1950) plant the same general results were obtained by using Hooker diaphragm cells for the electrolysis, but for the present extensions

mercury cells of the advanced Uhde design were chosen for two reasons:

(1) The mercury cell produces caustic soda of a higher quality than does the diaphragm cell, and Murgatroyd's can therefore enter fresh markets with the 'rayon-grade' material thus obtained.

(2) In working up the caustic soda liquor from the existing diaphragm cells, a grade of salt ('Salt B') is obtained which contains small amounts of caustic soda and is therefore unsuitable for foodstuff use. It can, however, be used as a raw material for the mercury cells.

### Brine supply

Salt (both premier-grade vacuum salt and the 'B' grade) is stored in bunkers, from which it is discharged by grab and conveyor belts into three concrete-lined tanks, where it meets a rising flow of the weak brine recovered from the mercury cells.

The resaturated brine is treated with metered amounts of barium chloride, sodium hydroxide and sodium carbonate in two mechanically-stirred rubber-lined tanks, to remove sulphates, magnesium and calcium, and weaker brine is added to adjust the strength of the solution. The liquid passes in succession through three reaction tanks, in which, assisted by compressed-air agitation, the precipitation of the impurities is completed. It is then forced through three rubber-lined pressure filters from which the pure and very clear brine runs to a header tank and thence by gravity to the mercury cells. The overall rate of flow is controlled by maintaining a constant pressure at the header, and each cell is fed through an accurately sized orifice.

### The mercury cells

A new two-storey building contains the mercury cells, arranged in batteries on the two main floors, with the liquor and gas manifolds on an intermediate floor. The cell house has been designed so that a duplicate installation can readily be added if required in future.

Each cell is 40-ft. long and consists of two very rigid mild-steel rectangular troughs mounted side by side to form the electrolyser and decomposer sections. Each cell is rubber-lined, and is mounted on concrete pillars supported on adjustable porcelain insulators. The top of each trough is machined flat and is closed by a flat rubber-lined cover plate, through which passes the copper busbar feeding direct current to the anodes. These anodes are drilled and grooved graphite plates suspended by insulated graphite rods, adjustable so that they can be positioned accurately.

The floor of the cell has a slight slope on which a thin layer of mercury forms the cathode. In operation, the resulting sodium amalgam is separated from the weakened brine by weirs at the end of the electrolyser section and is transferred to the decomposer. A vertical pump returns the mercury to the electrolyser when the amalgam has been decomposed.

The gas liberated at the anode of the electrolyser section is chlorine of not less than 98% purity. It is drawn off through ports at the end remote from the mercury pump, and passes into the chlorine manifold system. The weakened brine, saturated with chlorine, is drawn off at the same end as the chlorine, and flows to the dechlorination plant housed beneath the cells.

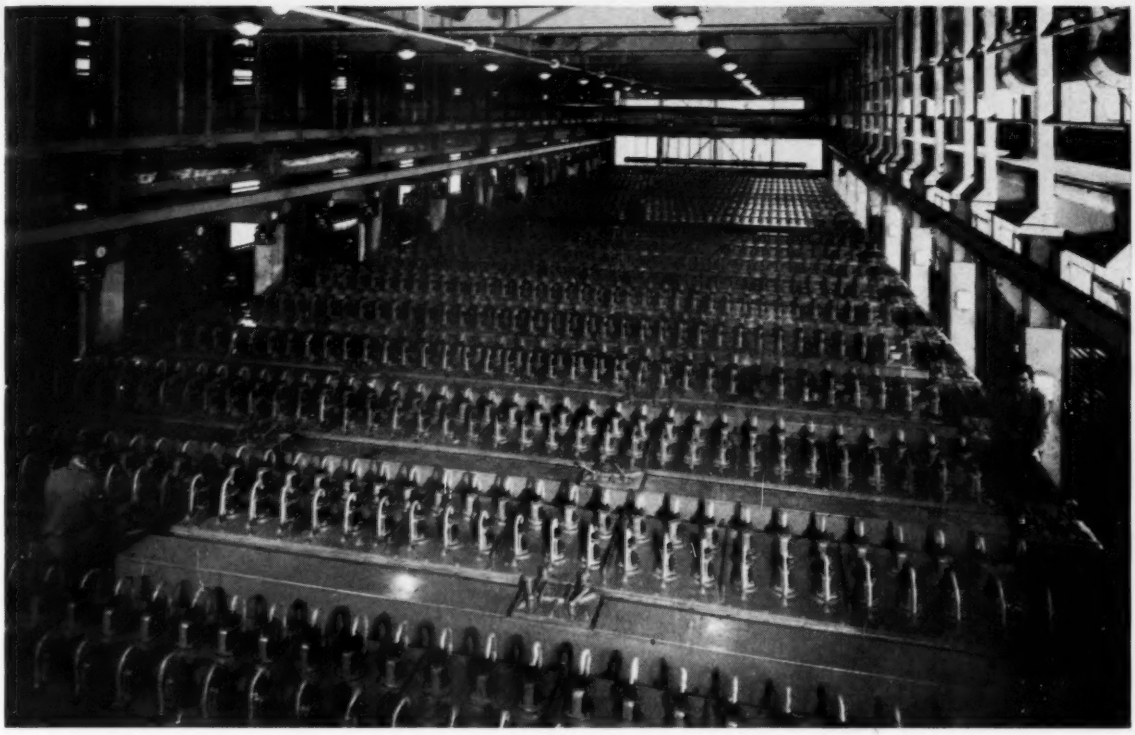
In the decomposer section, two sets of graphite grids form short-circuited cells in which the controlled supply of soft water reacts with the sodium amalgam, producing hydrogen gas and caustic soda solution; these leave the cell through a mild-steel riser and a mild-steel downflow, respectively, at the end next to the mercury pump. Control of the water supply is effected by a rotary distributor made of rigid PVC. The rate of flow of the water governs the strength of the resulting caustic soda solution.

Operation of the cells is controlled from a centralised panel on the lower floor. Routine checks are made on chlorine concentration, on sodium content of the amalgam, and on the composition of the residual gas. If the chlorine concentration is below the 98% limit, hydrogen content is also determined and the cell concerned is, if necessary, shut down for examination. For this purpose, and for regular cleaning and the replacement of graphite electrodes, a short-circuiting system is installed which enables any cell to be by-passed without affecting the rest. A signal bob shows when each mercury pump is functioning properly; if the pump fails, the cell is automatically switched out of circuit and an alarm bell rings.

### Brine dechlorination

The weakened brine, saturated with chlorine, runs from the cells through a manifold system to a preliminary separation tank in which gaseous chlorine is evolved; it then flows through a series of four rubber-lined mild-steel tanks, meeting a rising stream of air bubbles blown up through porous slabs in the bottom. The air passing out of the top of the tanks contains about 1% chlorine, which is recovered by absorption in milk of lime. The degassed brine is pumped back for resaturation with salt before re-entering the cycle.

Contact rectifier control room.



**A view over one complete floor of mercury cells.**

### Chlorine purification and liquefaction

The hot moist chlorine coming from the cells is at about 80°C. and is brought down to about 20°C. by indirect water cooling through glass tubes in rubber-lined cooling towers. It is then dried by passing through a series of towers in which it meets a countercurrent stream of sulphuric acid. Catchpot separators remove any spray, and the cool dry gas is drawn off by fans and passed to the south end of the works, where it is compressed and liquefied or may be converted into hydrochloric acid and sodium hypochlorite.

In the next stage, hexachloroethane, chloroform and other organic impurities are removed by scrubbing the gas with liquid chlorine in mild-steel purification towers, from which it passes to the first and second compressor units. The gas then enters a set of six vertical shell and tube coolers, using calcium chloride solution at 5°C. and with automatic control of the liquefaction pressure.

From the base of the liquefiers the liquid chlorine is passed through 5-ton weigh tanks to storage, consisting of three tanks sited below the liquefiers and two tanks newly erected outside the building.

From storage, the liquid chlorine is transferred by compressed air to the filling bay.

### Anhydrous caustic soda

The caustic soda from the cells passes through rubber-lined manifolds and intermediate collecting tanks to the main battery of rubber-sprayed storage tanks at some distance from the cell house.

The pure and almost anhydrous solid caustic soda is produced by taking a 50% solution from storage, preheating it by superheated steam, and then removing the water in a *Dowtherm*-heated climbing-film evaporator, operating under a vacuum. From the top of the evaporator the anhydrous molten caustic is passed to a *Dowtherm*-heated storage tank before final solidification. The whole of the preheater and evaporator plant is made from solid nickel; the storage tank is of nickel-lined steel.

### Modifications to existing plant

In addition to the new plant already described, modifications have been made to existing plant. The output of the earlier (1950) Hooker diaphragm cells has been increased by approximately one-third by the installation of mercury arc rectifiers. The existing caustic liquor evaporator capacity has been increased, mainly by raising the pass-out steam pressure to the first effect. General handling facilities, extensions to the refrigeration plant, new laboratories and new stores have also been provided.

### Electrical power

A very considerable supply of direct current has always been needed for the electrolytic processes; process steam and cooling water are also required in large amounts. In the original plant, a reasonable balance was achieved between steam required for processing and for power generation, but in the recent expansions electrical loading has increased proportionately more than has the demand for process steam. In consequence the extra electric power now needed is obtained from the national grid.

In addition, therefore, to the supply from the works' own power station, electricity is supplied by the Merseyside and North Wales Electricity Board into a 33,000-v. substation.

The power is transformed to 11,000 v. and fed to the d.c. rectifiers and to transformer substations which distribute low-voltage power to the plants.

Metropolitan-Vickers Electrical Co. Ltd. supplied the main 11-kv. switchboard (the two incoming units being the property of the Electricity Authority) and two control cubicles for contact rectifiers. The 11-kv. switchboard consists of nine 250-mva. duplicate busbar-type V22H1R units. The busbars are arranged in compound-filled chambers and are sectionalised with panel No. 6 arranged as a bus section unit. The circuit-breakers are of the vertical isolation type, electrically operated, and a system of interlocks ensures that they are racked up into the correct busbars. Maximum indication is possible through the large glass panels inset in the cubicle doors. The outgoing feeders are fitted with earth fault and overcurrent protective devices, and an audible alarm is given if any circuit-breaker should open under fault conditions.

The switchboard is complete with two busbar voltage transformers and two feeder voltage transformers for synchronising, instruments and metering, and is remotely controlled from a six-panel control board with illuminated mimic diagrams situated in the control room above the switch house.

The contact rectifier control cubicles, which are situated in the main transformer building, are each equipped with a 400 amp. electrically-operated type H1R oil circuit-breaker and 11-kv. fuse links. Both cubicles are mechanically interlocked with their feeder breakers in the main switchboard.

### Safety precautions

Full precautions are taken to avoid the potential health hazard presented by the considerable amount of mercury continuously in circulation. Mention has already been made of the automatic shutdown and alarm system which operates when a mercury cell pump fails. In addition, water seal-pots are provided wherever mercury vapour might possibly leak into the air. All floor drains in the cell building have at least two sumps to trap effectively any spilled mercury. Operators must change underclothing before entering the cell house. They wear protective clothing when on duty there, and take shower baths immediately on going off duty. All operators are medically examined at regular intervals.

The cell house itself has an open slatted wall on one side, with a slatted wooden walkway providing vertical ventilation on each side of the rows of cells, while a full-length ridge ventilator extracts air from the top of the building. Checks on the mercury content of the air form a routine precaution.

W. J. Fraser & Co. Ltd. were the main chemical engineering contractors for the expansion programme, which was co-ordinated by Murgatroyd's with the assistance of the Engineering Division of the Distillers Co. Ltd.

## Cutting Costs in Water Treatment

*Chlorine dioxide in waterworks practice*

Chlorine dioxide is now being used, in addition to chlorine, in more than 150 municipal waterworks in the United States and Canada. In most of these its principal function is to remove taste and odour under conditions where the breakpoint method of chlorination is not adequate, but it is also regarded as an effective bactericidal and sporicidal agent.

The subject of water treatment using chlorine dioxide was discussed by Mr. E. R. Woodward, chemical engineer of the Olin Mathieson Chemical Corporation, U.S., when he spoke before the annual meeting of the Pennsylvania Water Works Operators' Association. He said that, where the ammonia content of the water requires breakpoint chlorination for spore control, chlorine dioxide may offer a substantial advantage. The dioxide is also finding use in combating colour problems, and there have been instances where colour due to iron or manganese in the water has been removed by treatment with it.

Commenting on the economics of chlorine dioxide for water purification, Mr. Woodward pointed out that, in considering the chemical composition of water to be treated, ammonia is one of the chief constituents affecting cost. Breakpoint chlorination requires that the ammonia content of the water be converted to nitrogen trichloride. The theoretical ratio of chlorine to ammonia for this reaction is 10.4 to 1, so it is evident that water high in ammonia will require a large addition of chlorine before the breakpoint is reached.

Chlorine dioxide does not react with ammonia, and it is therefore available for oxidation of objectionable taste and odour-producing compounds.

The nature and degree of pollution also plays an important part. Chlorine dioxide acts primarily as an oxidising agent, whereas chlorine reacts first to form chlorine substitution products. For example, in a water containing phenol, chlorine will react to form chlorophenols until the addition of chlorine is great enough to break the benzene ring and form tasteless, odourless compounds. Chlorine dioxide, however, oxidises phenol, breaking it down to tasteless and odourless compounds without formation of objectionable intermediate products.

A similar situation occurs with water in which algae and actinomycetes are present. Algae give off certain chemical compounds which, upon chlorination, form chloro compounds much more objectionable than the original. In the case of actinomycetes, one of the products of decomposition is butylamine. This product is not destroyed by chlorine. In fact, its objectionable odour becomes more intense as chlorine dosage is increased. Chlorine dioxide will oxidise this taste and odour-producing compound to one that is completely inoffensive, according to Mr. Woodward.

In one case, chlorine dioxide was substituted for breakpoint chlorination and activated carbon, and daily chlorine consumption was cut from 1,080 to 162 lb.; activated carbon was cut from 1,800 lb. to nil and replaced with 46.2 lb. of sodium chlorite. Cost represented a saving of 72.5% of the original cost of treatment.

## Nomogram:

FOR carbonated aluminate solutions where sodium oxide is nearly constant at 56 to 58% and where carbon dioxide and alumina make up approximately 43%, Hall and Green[2] related density $d$, percentage of solids $w$, and temperature $t$, °C., by means of the expression:

$$d = (0.0129w \div 0.938)\,[1 \div 0.0007(80 - t)]$$

The use of the accompanying nomogram, designed[1] to solve this equation, is illustrated as follows:

What is the percentage of solids in a carbonated aluminate solution when the density is 1.220 at 35°C.? Connect 35 on the $t$-scale and 1.220 on the $d$-scale with a straight line and note the intersection with the $w$-scale at 19% solids.

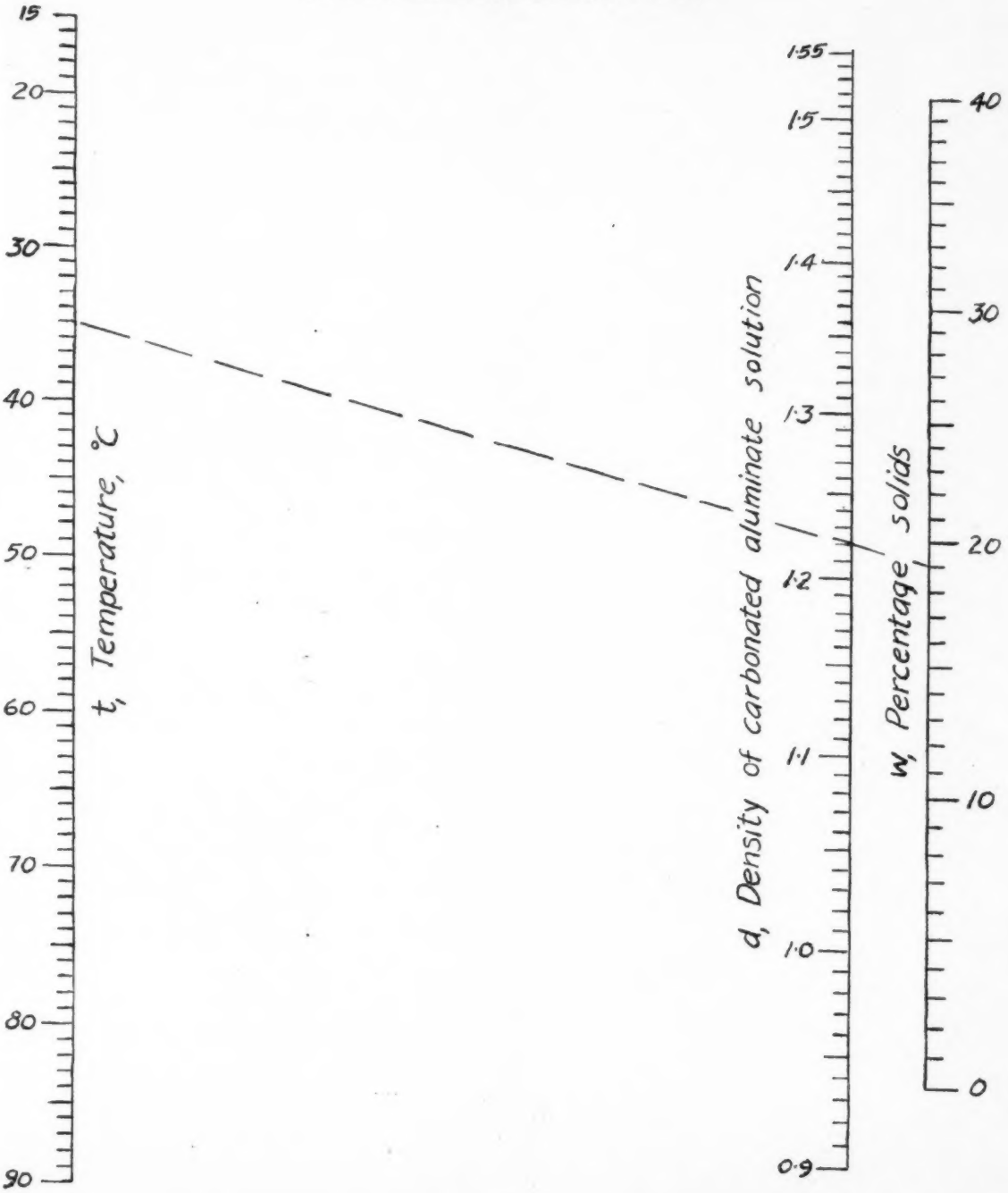
REFERENCES


[1] D. S. Davis, 'Nomography and Empirical Equations' (chapter 6). Reinhold Publishing Corp., New York, 1955.

[2] J. M. Hall and S. J. Green, *Ind. Eng. Chem.*, 1945, **37**, 977.

# Densities of Carbonated Aluminate Solutions

**By D. S. Davis**
(*Professor of Engineering, University of Alabama*)



## Phenol Recovery from Waste Liquors

*New German process shows promise*

CHEMICAL engineers working at the Leuna works in Eastern Germany claim to have developed a new method of phenol recovery which is much simpler and cheaper. Laboratory experiments have given good results and large-scale trials are to be undertaken soon.

When waste liquors are dephenolised by means of a solvent-effluent contactor* before they are discharged, extracts are obtained which contain considerable quantities of carbolic acid and of cresols. A recovery of these phenols from the extracts is difficult because they also contain neutral oils. Rectification by simple or azeotropic distillation is impossible, and the extraction of the oil with solvents does not give satisfactory results.

The only method at present used in the industry is complicated and rather expensive. It consists of the following four operations:

(1) The extracts are treated with caustic soda, which converts the phenols into sodium phenates.
(2) The neutral oils are distilled off, and the turbid liquid becomes clear.
(3) The phenate solution is treated with carbon dioxide, which converts the phenates back into phenols.
(4) The sodium carbonate solution obtained in operation 3 is causticised for re-use in operation 1 by heating it with slaked lime.

In the dephenolating tower the extracts are mixed with sodium carbonate solution. The extracts enter the column at the middle, the soda solution at the top. The mixture meets a counter-current of superheated steam at a pressure of 5 to 10 atm. Under these conditions the phenols react quickly and—for all practical purposes—quantitatively with sodium carbonate according to the equation:

$$2ROH + Na_2CO_3 = 2RONa + CO_2 + H_2O,$$

where $R$ represents a monovalent radical derived from an aromatic hydrocarbon, *e.g.* $C_6H_5\cdot$ or $CH_3C_6H_4\cdot$. This is the reverse of the reaction occurring at ordinary pressure when sodium phenate solutions are treated with carbon dioxide. The vapours leaving the top of the tower are condensed, and the condensate consists of two layers: a top layer, mainly oil, and a bottom layer, mainly water. The phenate solution collecting at the bottom of the tower is practically free from oil. When the pressure in the condenser is released, carbon dioxide escapes and is used to convert the phenates into phenols and to regenerate the sodium carbonate solution. The phenols can now be separated from each other by fractional distillation.

The following advantages are claimed for the new process:

(1) Two operations instead of four.
(2) A continuous method can be used, which is impossible with the old process because causticising requires a discontinuous method.
(3) The disagreeable causticising operation is completely eliminated.
(4) The only reagent required is steam.
(5) No waste product is formed.

The process was described by R. Bemman in *Chemische Technik*, 1956, **8** (10), 578.

*The latest American version of such a phenol extraction plant has been described in CHEMICAL & PROCESS ENGINEERING, 1956, **37** (11), 399.

## Refractive Index of Liquids at Elevated Temperatures

The refractive index of liquids is a physical property so easily determined with accuracy that it has become a standard for their characterisation. Accurate refractive indices, however, are difficult to obtain at temperatures much above ambient because of the difficulty of maintaining the sample and part of the measuring instrument at a uniform temperature. Reliable calibration standards are necessary before commercially available instruments can be used with confidence.

This is pointed out by J. J. Lauer and R. W. King in *Analytical Chemistry* for November 1956, and they go on to describe work with two instruments which have been constructed for the absolute determination of refractive index at elevated temperatures. One instrument is useful for determinations in the temperature range 25 to 55°C., and the other from 60 to 110°C.

With this equipment refractive indices were measured at elevated temperatures for three compounds of high purity intended to serve as calibration standards. Incidental to supplying data on these standards for laboratory refractometers, refractive indices were measured at several different temperatures and wavelengths for a number of hydrocarbons.

Neither of the instruments used, it is made clear, is suitable for routine measurements and the authors conclude with the hope that the description of their construction and operation will encourage further work of a fundamental nature in the field of high-temperature refractometry.

## New British Lampblack Factory

A new lampblack factory was completed during November at Basildon New Town, Essex, for the Ship Carbon Co. of Great Britain Ltd. Technically the process is a modern version of the traditional method of manufacturing lampblack in that it consists of subjecting selected oils to a process of incomplete combustion. During this process the hydrocarbons comprising the fuel undergo dissociation with liberation of carbon and hydrogen. The gases of combustion carrying the lampblack in suspension are led to a series of collecting units where separation takes place.

The whole process is rendered more complex by the presence of small quantities of sulphur gases from the sulphur compounds in the oil used as the raw material, and very careful precautions are taken in the factory to minimise dewpoint condensation and consequent corrosion problems.

With a difficult product of this sort, gaseous effluents require a very high degree of cleaning and particular attention has been directed to this with the aim of producing a final gaseous discharge to the chimney stack completely free from any solid or noxious constituents.

The whole of this work was completed one month ahead of the scheduled programme. The contract for the engineering and erection was carried out by W. J. Fraser & Co. Ltd., and certain major items of equipment were fabricated at their works at Monk Bretton, Barnsley, Yorks.

Lampblack is used in relatively large quantities by tyre and general rubber manufacturers, the larger of whom are regular customers of Ship Carbon.

# WHAT'S NEWS about

★Plant
★Equipment
★Materials
★Processes

This illustrated report on recent developments is associated with a reader service that is operated free of charge by our Enquiry Bureau. Each item appearing in these pages has a reference number appended to it; to obtain more information, fill in the top postcard attached, giving the appropriate reference number(s), and post the card (no stamp required in the United Kingdom).

## Additives cut fuel costs

Two fuel additives which are claimed to be capable of substantially reducing fuel costs are among a group of new products which also have qualities for the lessening of air pollution caused by incomplete combustion. The products, one for coal and solid fuels and one for diesel fuel oils, are designed to ensure complete combustion of the fuel, thus eliminating slag in one case and desulphurising residual oils in the other.

The combustion accelerator for solid fuels, it is stated, enables a high degree of thermal efficiency to be obtained when using the comparatively low grades of coal commonly used by industrial concerns.

The second fuel additive, for liquid fuels, is claimed to ensure complete inhibition of the formation of acid sulphur in residual diesel fuel oils, thus removing one of the chief causes of corrosion and of blocked injectors and nozzles, and one of the most harmful constituents of polluted air. A further feature pointed out by the makers is that it gives results equivalent to the reduction of viscosity by means of an additive, and its introduction therefore widens the range of application for lower-grade cheaper fuel oils which can be made suitable for equipment designed for more expensive fuels. Thirdly, the additive prevents and/or eliminates sludge, bringing a consequential reduction of maintenance charges and costly stoppage overhead charges. **CPE 449**

## Just fine for grinding

A small pin disc grinder, specially designed for laboratory- and pilot-plant use in testing small batches of new products, has recently been put on the market. It is claimed to be dustless in operation, measures 23¼ in. × 15¾ in. × 15½ in. and weighs 160 lb.

The fineness of the grind may be quickly and simply adjusted by changing the pin discs, while the mill incorporates no screens and is claimed to be completely vibrationless when running.

Though primarily intended for batch work, the mill may also be used as a production machine and a continuous rating motor is fitted for this reason. When sterile conditions must be maintained all contact parts are made in stainless steel and highly polished. Another valuable feature is the absence of heat during operation, which is of particular importance when low-melting-point materials are to be pulverised. **CPE 450**

**Pin disc grinding mill.**

## Corrosion-resistant thermoplastic

Essentially a rigid unplasticised material, based on polyvinyl chloride, *Cobex* is regarded by its makers as one of the most important of a range of thermoplastics. It is claimed to be ideal for deep-draw moulding, blowing and vacuum moulding. It is easily joined by cementing and hot-gas welding, and also by R.F. welding.

Its particular applicability to the chemical industry lies in its resistance

**C.P.E.'S MONTHLY REPORT AND READER SERVICE**

to the action of a wide range of chemicals, particularly inorganic acids, alkalis and aqueous salt solutions up to 60°C. Powerful oxidising agents, such as concentrated nitric acid, it is pointed out, do cause attack. It is also resistant to many organic liquids, although some ketones, chlorinated hydrocarbons and other compounds may cause swelling, particularly at high temperatures.

It has been used in the plating and anodising shops of chemical plant and as ducting to carry acid fumes. *Cobex* is classed as non-inflammable; when it is placed in a flame it will char, but this ceases as soon as the flame is removed. **CPE 451**

## Ups and downs

The introduction of a series of automatic oscillating hoists has been announced. They are intended for applications where it is necessary for the load to be automatically oscillated, and are in daily use over oil, water and brine quench treatment tanks, degreasing baths, etc.

The units may be manually controlled or switched over to automatic oscillation. Both the speed and magnitude of oscillation may be varied within wide limits. They have capacities up to 500 lb. and are normally fitted with four-wheel trolley sets. **CPE 452**

## Free piston gas generator

The *Pescara* free piston engine system is now being manufactured in the United Kingdom. One size of free piston gas generator will be produced at present—the model GS34, which can provide 1,000 s.h.p. in a single unit and up to 16,000 s.h.p. by the use of multiple units.

The free piston gas generator is in essence a highly pressure-charged diesel engine, in which the conventional internal combustion pistons are directly coupled to compressor pistons and by which, with complete elimination of the crankshaft, power gas is produced at high pressure for conversion into shaft power by an exhaust gas expansion turbine. As the turbine is operated by exhaust gas from the generator, only moderate temperatures are reached in the turbine blade system, greatly contributing to reliability.

The output from the turbine can be used to drive in the normal way machines such as electrical generators, compressors or blowers. **CPE 453**

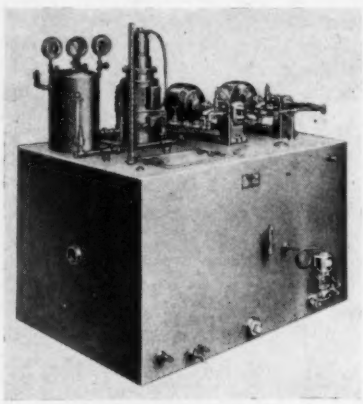
## Looking ahead in corrosion control

From the United States comes news of an instrument to measure rapidly the rate of corrosion in all types of metals subjected to the corrosive effects of various liquids or gases. In the short space of a few hours, users of the corrosion tester can predict the amount of corrosion that may take place in five or ten years of field use.

The instrument is, basically, a sensitive electronic Wheatstone bridge circuit. Probes have one protected corrosion strip and one exposed corrosion strip. Automatic temperature compensation is obtained from the protected strip. The corrosion on the exposed strip causes the meter to indicate directly in micro inches of corrosion.

Probes holding the protected and unprotected metals are available in all types, for long or short test periods. Probes are also designed for high or low temperature testing, either in the laboratory or field.

Some of the potential applications are: (1) Determining the corrosion rate of materials to be used in chemical reactors, mixers and processing lines of various types; (2) determining the corrosion-inhibiting characteristics of gasoline additives; (3) determining the corrosion-inhibiting characteristics of oil additives; (4) determining the corrosion-inhibiting characteristics of rust inhibitors added to auto radiators and various other processes, such as boilers; and (5) determining the effectiveness of cathodic protection devices. **CPE 454**



### CLEANS AND CIRCULATES OIL

*Available in a wide range of types and sizes, dual self-contained lubricating and filtration units are particularly recommended and ideally adapted for installations where quantities of sludge, water or other foreign substances are present in the oil. By using two receiving tanks, the foreign substances in one batch of oil are permitted to precipitate while the clean oil in the other tank is being circulated through the system. Dual tanks are complete with steam coil, temperature regulator, clean out, draw-off cock, oil level indicator, thermometer and threaded connections for attaching the necessary piping.* **CPE 455**

## New heat-resistant material

A development of *Devcon* plastic steel has produced a tough, heat-resistant material, *Devcon C*, a liquid consisting of approximately 80% aluminium and steel and 20% plastic, to which a hardening agent is added. The mixture is poured, and forms in or around a model. When hard, it is lightweight, resembles aluminium in many respects, and can be worked with general metal-working tools. It has a compression strength of over 5,000 p.s.i. at 400°F.

It has been found that two sections of a die for a high-impact plastic compound can be made without highly skilled labour in less than 2 hr. **CPE 456**

## Valve welding

An installation for welding flanges to valve casings has been developed and consists of a welding head mounted on a pedestal which has hand-operated height and longitudinal adjustment of 10 in. and 16 in., respectively. The welding head can thus be positioned accurately over the work.

A curved nozzle is used to give access between the flange and the valve casing. The controls for the welding head are mounted on the pedestal.

The equipment is used in conjunction with a standard 10-cwt. manipulator, the rotation of which is electronically controlled by remote push buttons at any selected speed between 0.05 and 0.95 r.p.m.

The same installation can be used for welding a wide range of components on which circumferential welds are required; this would usually only mean using suitable locating jigs on the manipulator faceplate. **CPE 457**

## Packaged boilers and 'packaged service'

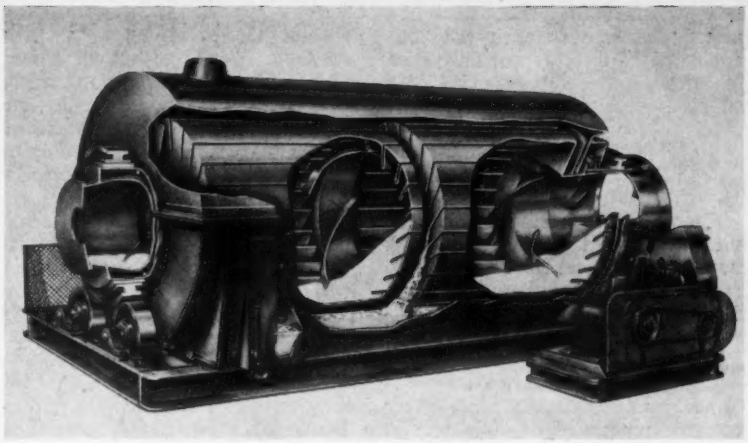
A *Minipac* packaged boiler has 'unitised' fully automatic control, the various controlling mechanisms being in five separate boxes mounted on the boiler frame and 'plugged in' to a connection box. In the event of failure of any one of these units, it can be quickly substituted by a replacement unit while undergoing repair. 'Packaged service' can therefore be afforded to the automatic control gear of the boiler, eliminating the possibility of lengthy out-of-service periods due to control failure and the absence of skilled electronic engineers on site.

The boiler is totally enclosed, with all auxiliaries built in. Two main flue tubes are fitted with special pressure-jet oil burners giving a short non-luminous flame, and fire tubes form a second pass for the combustion gases, providing maximum heat transfer. The boiler uses gas oil or diesel oil without oil heating. It can also be arranged for light residue oils.

Small floor-space requirement is a feature of the unit. The 5,000-lb./hr. boiler requires only 55 sq. ft. No special setting is required, and the boiler can be delivered to site steam-tested and ready for immediate use after connection of the usual mains and outlet. The *Minipac* is manufactured in a range of sizes from 3,500 lb./hr. for working pressures up to 250 p.s.i. **CPE 458**

### CORROSION-RESISTANT TRUCK

*The container of this wet-goods truck, which is used for handling bundles of fabric in the dye house at the Calico Printers' Association Ltd., is moulded from* Bakelite *polyester resin reinforced with glass-fibre material. Polyester/glass is used for the container on account of its lightness and strength and its resistance to the chemicals used in the dyeing process; the chassis is made of corrosion-proof steel.* **CPE 459**



**Cut-away view of the two-stage rotary louvre cooler.**

## Rotary louvre cooler uses water as medium

A new cooler is being introduced which operates on a rotary louvre principle as regards movements of the material but uses water as the cooling medium.

The accompanying illustration shows a two-stage cooler with its outer shell cut away to show the internal construction. The two drums are also partly sectioned to show the relationship between the cooling louvres, the bed of material being cooled and the circulating water.

The drums, revolving slowly on a horizontal axis, are partially immersed in a water bath from which they collect water in the hollow tapering louvres. The collected water flushes along the louvres in contra flow to the movement of the material, so giving a high degree of heat transfer.

The water bath is split into stages, a water-level control determining the flow rate of the cooling water through the unit. The water enters the bath at the end of which the cooled material is discharged, leaving it at the opposite, or material, feed end. Some evaporation occurs on the outside of the louvred drums, which assists the cooling operation, the resulting vapour being discharged through a vent at the top.

The hot material is fed in through an opening on the centre line of the cooler and immediately takes position as a moving bed based on its angle of repose. The hollow louvres in each stage are deeper at the feed than discharge end, so that they not only assist positive movement of the material through the unit but provide the required head for flushing the water. As the drums revolve, the louvres enter the bed of material, providing intimate contact and producing gentle movement of the material from the bottom to the top of the bed. The uppermost particles gently roll over, maintaining the angle of repose with a spiral movement of the material from feed to discharge end, assisted by transfer vanes between the first stage and the second. There is no avalanching or cascading, friable materials being handled with minimum breakage, the makers state.

The depth or quantity of material in the cooler determines its retention time, and this may be varied by adjusting the discharge vanes. Another adjustment of these vanes assists emptying.

The rotary water louvre cooler is manufactured in either one, two or three stages and in a range of diameters and lengths. It is suitable for most crystalline granular or powdered materials, provided they are not of a sticky nature. When handling materials containing moisture which will evaporate during cooling, low-velocity air can be passed through the cooler, leaving it *via* the top vent.

Normally the parts in contact with the material are of mild steel, stainless steel or aluminium, the water bath and its enclosures being of galvanised mild steel.

Since the cooler drums rotate on roller bearings at a slow speed, the horsepower required to drive them is low and the electrical consumption therefore quite small. Moving parts are few and maintenance is negligible.

Water consumption is also low and

it is worth noting that, since the heated discharge water is not contaminated, it can be profitably used for other purposes. **CPE 460**

## Metal just folds up

Hand-operated folding machines for sheet-metal work are available in a large variety of sizes from 3 to 10 ft. to handle sheet metal from 18 to 12 S.W.G. with virtually unbreakable all-steel construction, fitted with adjustable tie rods and strongly braced.

Accurate bends and folds are ensured by such features as the stop for uniform repetition bending with a front folding leaf adjustable for sharp or round bends. The clamping beam can be adjusted rearwards, forwards and in a vertical plane, allowing for variations in material thickness, and alignment of the bending edge. Heavy adjustable counterweights facilitate working and obviate fatigue of the operator. **CPE 461**

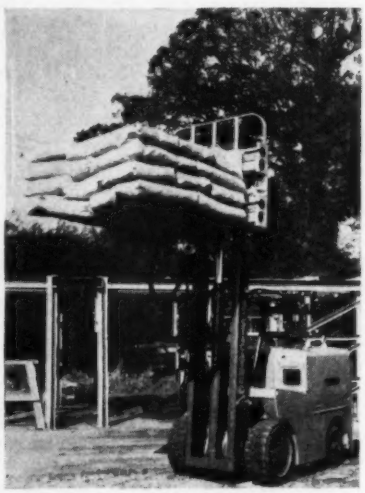
## No pallet for mechanical handling

A new method of palletless fork truck handling has been introduced to the United Kingdom. It is called the *Accopak* system and involves merely the use of a number of paper slings in conjunction with a fork truck ancillary attachment.

In this method of palletless handling the slings are used in place of normal pallets, and are made from a sheet of kraft paper suspended between two paper tubes measuring approximately 3 in. in diameter. Each sling supports a load which would normally be carried on a pallet, and it is lifted, transported and stacked by means of circular tines which are inserted in the tubes. These tines, measuring 2 in. in diameter and 52 in. in length, are manufactured from high-grade manganese-molybdenum alloy steel with a high tensile strength of 55 to 65 tons p.s.i. and are fitted to the *Hydrum* load clamp instead of the normal clamping arms, with which they are, however, easily interchangeable.

Entry of the tines into the tubes of the slings is facilitated by the fact that one tine is 2 in. longer than the other, thus allowing it to be located in one tube first, the second being adjusted laterally by means of the independent arm control on the clamp. Horizontal movement can be applied independently to either arm to give a total combined range of movement from a minimum of 17 in. to a maximum of 60 in. between the tines.

The makers point out the economic advantages of this system, the cost of paper slings being negligible compared with the cost of pallets, while, in addition, an increase in storage capacity of approximately 25% is made possible by the fact that the 6 in. taken up by each pallet can now be occupied by an extra layer of sacks. **CPE 463**



**Truck with full *Accopak* load.**

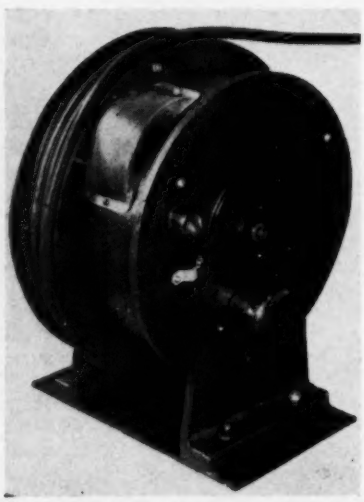
## Cable reel avoids fire hazard

The presence of fine particles of dust in the atmosphere as a result of a number of chemical processes constitutes a grave danger of fire. The use of dust-tight equipment suggests itself as a means of overcoming this problem with the employment of dust-extracting plant as a secondary precaution.

After all possible care has been taken in preventing dust formations, the second step is to ensure that the temperature never rises to ignition point by open lights, fires or smoking. Even a spark from iron bootnails on concrete has been known to start a fire and any electrical plant in use where there is this dust risk must be of a type incapable of igniting the dust.

In this connection, mention may be made of a contactless self-winding electric cable reel which has been specially employed for use in such circumstances.

The design is similar in appearance to the normal slip-ring-equipped pattern available from the same source, but the rubber cable is not broken between the point of contact with the machine being supplied with current and where it is connected up to the electric supply point. The advantages of this design are obvious where operating conditions are bad and where dust might easily penetrate to the contact surfaces of the slip-ring gear. There is also another interesting version in which the cable is paid off in opposite directions, *i.e.* double acting, but in this case the trailer reel must move along the r.s.j. which carries the hoist, otherwise the cable attached to the supply point would sag as it is paid off the drum. **CPE 462**



**Contactless self-winding reel.**

## Aids to analysis

Now available in the United Kingdom is a range of spectrophotometers produced in Germany. The range includes the popular DK 2 model described by the makers as a double-beam ratio recording spectrophotometer with exceedingly high resolution. This instrument is useful for spectrochemical analysis and research. Attachments include flame accessory, time-drive attachment and reflectance attachment, while its advantages are freedom from source fluctuations, independence of amplifier gain and a range of scanning speeds from 4 min. to 6½ hr.

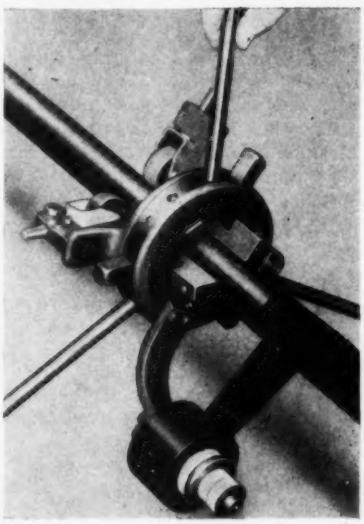
In the same range a model DU is used for qualitative and quantitative analysis of liquid, solid and gaseous

samples. It also permits the analysis of multi-component samples, thus eliminating painstaking preparations. The instrument can be used with a wide variety of attachments for flame analysis, reflectance measurements, fluorescence measurements and spectral energy recording. A DU photomultiplier combination which facilitates measurements at low intensity is also available. **CPE 464**

## Wrapping it up

An obvious way to protect underground pipes against corrosion is to wrap them up. But this is easier said than done because the material they are wrapped in has to be resistant also. However, a firm of tape manufacturers have put on to the market tapes which they claim have not only a remarkable degree of toughness and insulation, but also are resistant to the action of acids, alkalis, fungi and bacteria. They are claimed to last between 30 and 40 years underground.

These tapes are also claimed to give a high degree of conformity to angles, irregular surfaces, junctions, etc., and this conformity varies very little with climatic conditions. This means that the tapes can very easily be applied out of doors.



Pipe-lagging machine.

The same company which manufactures the tapes has developed a pipe-lagging machine with a quick-acting, self-centring gripping device, so that, once locked in its correct position, the lagging is effected with the exact amount of overlap required throughout the length of the run. **CPE 465**

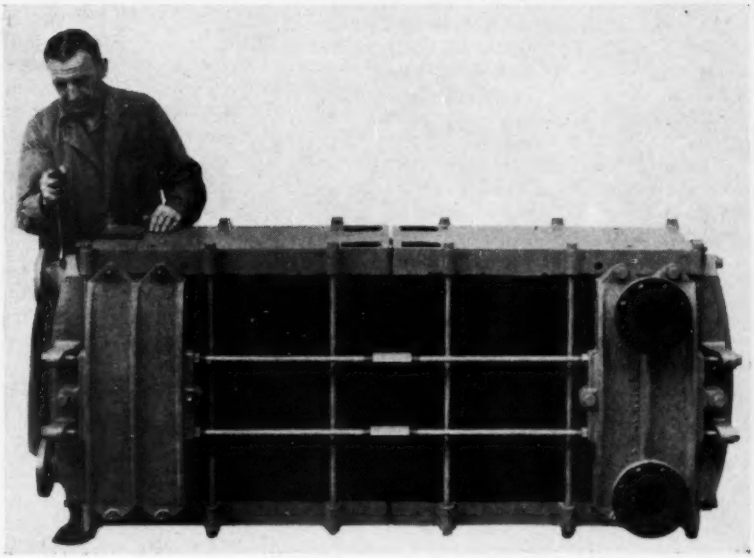
## Heat exchange with graphite

The successful use of graphite cubic heat exchangers in industries confronted with corrosion problems has created a demand for graphite block exchangers with larger heat-transfer areas and larger tube diameters.

To meet this need a series of large, rectangular, graphite-block heat exchangers has been developed and is now available.

The new series consists of three standard models with effective surface areas of 100, 150 and 200 sq. ft. and tube or hole diameters of $\frac{3}{4}$ in.

Multiple-pass arrangements of up to 16 passes on either side are available to suit the flow rates of both liquors and to ensure minimum pressure drop, according to the makers' description. They go on to state that there are no floating or flexible parts and that the new series embodies all the advantages of corrosion resistance on both sides, high thermal conductivity, compactness, robustness and ease of maintenance. **CPE 466**



A large graphite block heat exchanger.

## Plasticisers

The *Citroflex* plasticisers comprise a series of compounds, all of them esters of citric acid, compatible with most of the polymers generally employed in the plastics industry. They are five in number and can be readily identified by their numerical suffixes, which indicate the number of carbon atoms contained in the alcohol used for esterification. Acetylated esters are denoted by the letter 'A' appearing before the number.

The principal member of the group is *Citroflex* A-4. This compound is noted particularly for its pharmacological safety, its lack of odour and its lack of extractable taste, properties which make it an ideal plasticiser for materials prepared for use with foodstuffs. It is also used in the manufacture of polyvinyl toys and tubing for medical purposes.

Stocks prepared with this general-purpose plasticiser process may be very easily milled into sheet and film. Cellulose nitrate films plasticised with this ester have a lower volatility loss, higher resistance to yellowing, and adhere better to metals than those prepared with dibutyl phthalate.

When a polyvinyl chloride resin is required with very low plasticiser volatility coupled with good properties at low temperatures, *Citroflex* A-8 is recommended. Loss from polyvinyl chloride due to volatility, when plasticised with this ester, is reduced to about one-quarter of that occurring when the same percentage of di-2-ethylhexyl phthalate is used. In addition to its use as a plasticiser, the ester has been used successfully as a stabiliser for polyvinylidene chloride.

The third, and last, of the acetylated

esters of the group is *Citroflex* A-2. It is a solvent plasticiser for cellulosics, ideal for the preparation of cellulose acetate compositions with low warping characteristics, and particularly suited as a plasticiser for ethyl cellulose. Lacquer formulations, requiring light-fast properties, can be plasticised, and the product has been patented in the U.S. as a stabiliser for polyvinylidene chloride.

*Citroflex* 2 is sparingly soluble in oil and is of use in enhancing the grease resistance of formulations. It exhibits a high degree of compatability with vinyl resins and cellulosic derivatives, being especially useful as a solvent plasticiser for cellulose acetate and other cellulosic derivatives. Natural resins such as damar and ester gums are soluble in it, and its light-fastness is of value in lacquer formulations. It does not support fungal growth.

The fifth member of the series, *Citroflex* 4, is of use as a plasticiser for vinyl resins and cellulosics. It is an efficient defoaming agent for protein/protein solutions and gives improved light stability in cellulose acetate.

**CPE 467**

## Solenoid-operated pilot valves

Three new solenoid-operated pilot valves have maximum working pressures and bores as follows:

| *Description* | *Bore* | *Max. working pressure* |
|---|---|---|
| High pressure .. | $\frac{1}{16}$" | 250 p.s.i. |
| Low pressure .. | $\frac{1}{4}$" | 80 p.s.i. |
| Extra low pressure | $\frac{3}{16}$" | 15 p.s.i. |

The valves are of the 'glandless' poppet type of actuator of advanced design and performance. All units are stated to be suitable for use with compressed air, hydraulic oil and vacuum.

**CPE 468**

## Direct-reading contents gauge

There are many instances where it is desirable to mount a contents gauge indicator directly on the top or side of the tank and it is for this purpose that the direct-reading gauge has been designed by a British firm.

Unlike most gauges of this type, which depend for their indication upon some form of gauge glass filled with mercury or other liquid, this direct-reading gauge indicates tank contents directly by means of a pointer on a circular dial.

Mounted in the tank is a float which rises and falls with changes in the level of the liquid. The float arm is connected by means of a linkage and push rod to the indicator which can be mounted either on the side of the tank or on an extension arm above the tank.

The gauge is available with indicators of 4 in., 6 in. or 12 in. diameter. Each dial has a scale extending over 300°, thereby ensuring accurate indication of tank contents.

The gauge may be fitted with electric contacts for actuating alarms or for starting and stopping pumps and compressors. For such purposes, a double contact of the open type is usually supplied and this is adjustable from the front of the instrument. A suitable relay would normally be necessary for the operation of pump motors, etc.

**CPE 470**

Contents gauge.

## Air comes clean

Ensuring air free of dust, dirt, smoke, bacteria and other airborne contaminants, an electronic air filter which has recently been introduced into this country is particularly suitable for use in industries where a high degree of clean air is required, though it is pointed out that it is essentially a unit for applications in which the total dust loading is substantially less than that occurring in heavy industrial plant.

Its advantages are claimed to be that it eliminates product contamination, reduces maintenance and cleaning costs and improves working conditions. Using the principle of electrostatic precipitation, the filter collects all airborne contaminants regardless of size, including particles less than one-hundredth of a micron in size.

**CPE 471**

## Water temperature controllers

The principal features of the Samson self-operated water-temperature controller are as follows.

The standard pattern allows reduction of thermostat temperature up to 50°F. at a time (or up to 100°F. with a special model) without the need for first cooling the system.

It gives safety of thermostat against excess temperatures up to 90°F.—or up to 180°F. with the special model mentioned above.

It gives visual control of thermostat on a round dial temperature scale calibrated in °F., adjustment of the setting needle being by loose key.

Three types of valve are offered—

## New lease of life for a bucket elevator chain

Lack of effective lubrication for a bucket elevator chain working under severe conditions proved expensive. The conveyor transferred coal from a railway track to the top of the plant's silo and the coating of coal and atmospheric dust on all moving parts greatly increased friction and wear of components. The severe abrasion on all metal surfaces quickly ruptured all the ordinary lubricants tried.

The problem was eventually solved using a dispersion of *dag* colloidal graphite. The liquid carrier provided good wetting action and, though volatile, remained long enough to enable the colloidal graphite particles to reach even the most inaccessible part of the conveyor chain. The company reported that the colloidal graphite produces on rubbing surfaces a graphoid film that resists oxidation, inhibits corrosion, eliminates sticking and reduces friction.

**CPE 469**

including one (up to 4 in. in size) having a fully balanced single-seat valve that shuts off dead tight on relatively high flow pressures.

The dial control can be supplied separated from the immersion thermostat, connection being by a length of capillary tube, thus allowing control to be made from a point remote from the fluid (or other medium) which is being temperature controlled.

**CPE 472**

## Vacuum cleaner and blower

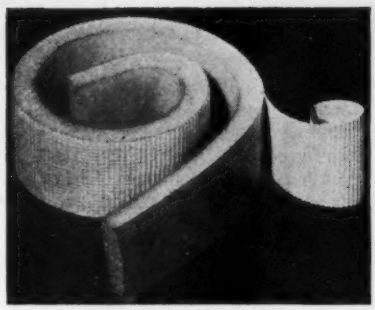
A lightweight and compact vacuum cleaner/blower of considerable power with a weight of under 30 lb. is suitable for ' haversack ' operation on the operator's back.

This latest unit is essentially an industrial machine and is consequently capable of continuous duty. The powerful exhauster/blower moves 50% more air through the lightweight 1½-in.-bore hoses. Cleaning is, therefore, much more rapid, reducing labour costs and enabling the operator to cover a greater area in a given time. Dirt and dust is collected in the metal container which provides easy and hygienic means of disposal. High-level cleaning is carried out from ladders or walkways, using hard-wearing industrial-type tools. Soft bristle brushes are supplied for delicate surfaces. A new, highly efficient floor nozzle is provided for floor cleaning. Crevice tools and blowing nozzles are also provided as standard equipment, enabling all surfaces to be satisfactorily cleaned at high speed. **CPE 473**

## Forced-circulation boiler

Advanced steam conditions will come into operation with a forced-circulation boiler plant which is being built as an extension of the ' B ' power station at the Margam steelworks in South Wales. It will generate 240,000 lb./hr. of steam at a pressure of 3,300 p.s.i. and a temperature of 1,060°F. with reheat to 840°F.

The boiler has been developed from British designs patented by Mark Benson over 30 years ago. For steam generation at pressures near, at and above the ' critical pressure ' it is said to have great flexibility of operation as well as speed and economy of construction and maintenance. Though of British origin, this type of forced-circulation boiler has until recently been developed and established mainly in Germany. **CPE 474**



**Self-adhesive foam.**

## Foam sticks to its job

A synthetic product which seems destined to penetrate to more and more branches of the chemical industry is *Stick-a-seal* self-adhesive polyurethane foam. Already widely used in the domestic field as a draught and dust excluder, it is now obtainable in a range of thicknesses and widths suitable for application in many industries. Flour, cement and powder mills have found this product useful for sealing off and separating grinding chambers, for sealing inspection covers and generally as a barrier seal against leakage and mixing of airborne powders. Used in strips and pre-stamped gaskets and shapes, this plastic foam has many applications in engineering for mounting and bedding down units and components.

The foam material which forms the base of *Stick-a-seal* is one of the polyurethanes created by mixing together a liquid alkyd resin, a di-isocyanate and free water in proportions and conditions to give a flexible and resilient foam. This lightweight, low-density foam is odourless, hygienic and non-irritant. Manufactured entirely from inorganic materials, it is rot-proof, will not support fungoid or bacterial growth and has no attraction for insects and vermin. The foam is translucent to *x*-rays. A characteristic of polyurethane foam is its high degree of chemical and physical stability.

Self-adhesive polyurethane foam is produced in standard thicknesses of $\frac{1}{8}$, $\frac{3}{16}$ and $\frac{1}{4}$ in., but thicker grades can be specially made. There are a variety of widths readily available up to 4 in. wide, but it may be obtained up to a maximum of 19 in. wide. Length of roll is from 13 to 25 ft., depending on thickness of foam. **CPE 475**

## Automatic control of bunker filling

Fully automatic control of bunker filling and conveying installations, it is claimed, can now be assured by the use of the *Maihak* bunker-level indicator, now introduced to the U.K.

This equipment, which controls the filling level of fine- and coarse-grained bulk mass such as coal and coal dust, grain, sawdust, soap flakes, dried milk, cement and plant husks, etc., takes the form of a synchronised motor-driven paddle fitted to the bunker. The paddle, the shaft of which can be anything between 8 in. and 20 ft. long, protrudes into the bunker space. When the material reaches the level of the indicator the paddle is arrested, displacing the wormshaft endwise and tripping the mercury switch.

The mercury switch can be connected to various instruments and can, if desired, automatically control the pump or conveyor motor by a contactor switch.

Once the level of the material in the bunker falls below the tip of the paddle, the paddle rotates and reverses the mercury switch.

Signal equipment is available in the form of horns and/or lamps.

**CPE 476**

## New hose coupling

Made of nylon, and of unique design, a hose coupling is being introduced to this country which is already in use in the leading steel mills and coal mines of Europe for air and water lines, while its applications also concern agriculture, domestic water supplies, irrigation, civil engineering and building contractors, fire-fighting services, factory installations, the brewing and chemical industries, and the services.

The coupling operates in the following manner. The female end fits to a supply point or tool. The other end, without being disconnected, accepts the free end of the hose, and the body portion of the coupling is screwed up by hand until the hose is securely locked. In this action the hose is progressively held by a helical internal steel spring. The interior of the body being of conical section, a perfect fit and lock is thus made as the body section is screwed up.

Important advantages resulting from this design are that, for a given inside diameter, the coupling can accept hoses of widely varying wall thick-

nesses (or outside diameters). Connection is a matter of seconds. The coupling need never be dismantled, and therefore there are no parts to be mislaid or damaged. No special tools are required for attachment. No preparation of the end of the hose is needed.

The coupling is now available for hoses up to 1 in. inside diam. and to withstand air and fluid pressures of up to 200 p.s.i. It is also available in a form for connecting two lengths of hose together and, here again, the coupling does not have to be taken apart for the joint to be made.

**CPE 477**

## New siliconate for masonry treatments

Useful for making building materials water repellent is a highly alkaline solution of sodium methyl siliconate which, when applied to masonry, lines the surface pores with a thin water-repellent film which does not change the appearance or breathing characteristics of the masonry.

It is at present recommended for evaluation as a treatment for brickwork and concrete where the use of organic solvent solutions of silicone resins is not acceptable. It has certain advantages over these latter—it can be applied to a wet surface and, as it is water soluble, can be used in admixture with cement. The new product has been found to be particularly effective on Clipsham and Portland limestones. **CPE 478**

## Temperature controller

Operating on what is claimed as a revolutionary new principle, a self-contained direct-deflection instrument indicates and controls temperature to close accuracy over a wide range in strict accordance with a predetermined time programme, according to the makers. It is used mainly for controlling the heating and cooling cycle of a furnace load and its operation is such that the load is automatically heated at a predetermined rate, held at the soaking temperature for a given time and then cooled as required.

The new principle utilises a transistor and, in consequence, the need for thermionic valves, magnetic amplifiers and oscillator circuits has been eliminated.

It incorporates a conventional galvanometer, used as the measuring system, and an indicating pointer which operates a simple photo-electric system and controls the heating medium. **CPE 479**

### THIS WILL FLOOR YOU

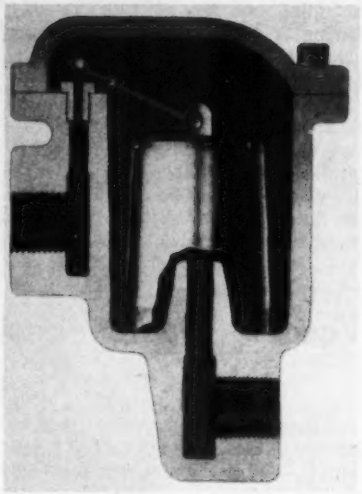
In the 15th century the monks of Beaulieu Abbey constructed a floor of ceramics fitted into an iron hexagonal honeycomb reinforcement. Now a British company is marketing the modern development of this old principle under the name of *Hexmetal* and claims that it can cut floor installation costs and stoppage time in a wide variety of industries.

The principle of this flooring is that ' precracking prevents subsequent cracking.' It is a fabrication of steel-walled honeycomb cells which when loaded with a filler acts both as a binder and as a separator. It absorbs impact load and vibrations and inhibits cracking caused by corrosive spillage. For this reason it has proved successful for heavy industrial plant and refineries, as well as for other industries. **CPE 480**

## Level indication

The *Telstor* continuous-level indicator is designed for use with liquids, powders and bulky solids, almost regardless of viscosity, density, conductivity and insulating value, and in conditions of pressure or temperature removed from atmospheric, it is claimed. Level variation can be measured over the whole container or a very small part of it, as desired. The interface between two immiscible liquids can also be followed, even in a sealed container.

The equipment consists essentially of an oscillator feeding an a.c. bridge with two capacitive arms. One arm is formed by the capacitance to earth of the level-measuring electrode. Out-of-balance voltage, caused by the electrode's change of capacity due to the rise or fall of material around it, is rectified and measured on a moving-coil meter. Two pre-set controls are provided for adjustment at installation. One adjusts the equipment to zero when the container is empty and the other is for ' full ' adjustment. The arrangement is made inherently stable by a stabilising circuit which ensures constant calibration notwithstanding mains voltage and frequency fluctuations, and valve ageing. **CPE 482**



### INVERTED BUCKET STEAM TRAP

*This new design of inverted bucket trap has a double leverage action which enables large-diameter seatings to be used, giving an extraordinary large capacity-to-size ratio.*

*Made in cast iron for pressures up to 200 p.s.i.g. saturated, it is available in ½-in., ¾-in. and 1-in. sizes. The ¾-in. to 1-in. size weighs only 7 lb. and can be suspended on the pipeline. The ½-in. trap weighs only 4 lb.*

*All the internal fittings, with the exception of the float (which is made of copper) are stainless steel, and it is hoped that before long the trap will be available with stainless-steel float.* **CPE 481**

## Feed-water treatment for low pressure boilers

New boiler feed-water treatments which are efficient for boilers in all pressure ranges, including high-pressure and flash-type boilers with steam-raising power from 25 to 30 times, and even 40 times, their heating surface, represent the radically new principles of feed-water treatments which have been developed on the Continent.

The new treatments are sold in water solution, which, it is pointed out, makes them easy to feed and ensures accuracy, while economy and simplicity of application are claimed as further advantages.

**CPE 483**

# World News

### NETHERLANDS

**Urea plant on stream**

A large new urea plant went on stream recently at the nitrogen-fixation works of Staatsmijnen in Limburg. Until then there had been pilot-plant production. The new plant is expected to have a capacity of 50,000 tons p.a. in the near future.

The urea will be sold for fertiliser and cattle fodder purposes as well as for technical applications.

**Research institute agreement**

N.V. Onderzoekingsinstituut Research, the research institute of A.K.U. (Algemene Kunstzijde Unie N.V.), Arnhem, has concluded an agreement with the Spencer Chemical Co., Kansas City (U.S.), under which it places at the disposal of the Spencer Chemical Co. its knowledge and experience of the manufacture and use of nylon 6 granules (*Akulon* granules). The latter company is now also entitled to use N.V. Research's patents in this field in the U.S.

### NORWAY

**Big oil refinery planned**

Norwegian government departments are studying proposals by Standard Oil, of New Jersey, for building an oil refinery in Norway. The proposals submitted by Standard Oil envisage a refinery with a capacity of about 2 million tons p.a. of raw oil. Costing almost £11 million, the plant would employ between 300 and 400 workers. It would probably be erected on the east side of the Oslo fjord. Most of the output would be distributed in Norway through Norsk Esso A/S, and any surplus would be marketed in Denmark and Sweden. Norway's only oil refinery at present is Norsk Esso's, with a capacity of about 100,000 tons p.a. Norway imported refined mineral oil and mineral oil products last year amounting to almost 3 million tons and costing foreign currency equivalent to £23½ million.

### PERU

**Oils and fats projects**

A factory under construction in Lima by Detergents, Oils and Fats Industries S.A. (Dorfisa) is scheduled to come into production shortly. It will produce some 2,000 tons of sperm oil and about 6,000 tons of castor oil annually, as well as quantities of sulphuric acid and detergents for the textile industry.

Kahn & Co. S.A., of Iquitos, in eastern Peru, are constructing a factory in that city for the production of edible oils. Initial output will be 2½ tons/day of cottonseed oil, and will later include peanut oil.

**CROSFIELD FACTORY DEVELOPMENT**

**An impression by the architect Mr. D. G. MacGonville, A.R.I.B.A., of the proposed extensions to the factory of Joseph Crosfield & Sons Ltd., at Warrington, which are referred to on another page. The factory has been designed by a team of company technicians and engineers.**

### BAHRAIN

**Platformer unit converted**

The No. 1 platformer unit at the Bahrain Petroleum Co.'s refinery is to be converted and, by July 1957, will produce 11,000 bbl./day of 90-octane (straight, unleaded) petrol by the use of a platinum chloride catalytic agent. This high-octane fuel will be used to raise the octane value of some of the petrol produced in other sections of the refinery.

### WESTERN GERMANY

**Nitrogen industry**

Rapidly increasing exports enabled West German nitrogen producers to keep their domestic prices stable for almost four years in spite of steadily rising production costs. Exports of pure nitrogen in the 1955-56 fertiliser year (which ended on June 30) amounted to 293,000 tons, compared with domestic sales of 472,000 tons in the same period. Sales abroad in 1954-55 were 256,000 tons and in 1953-54 only 190,000 tons.

However, exports are expected to become more difficult in the future, mainly due to growing competition from the United States. The American market is now almost lost because the U.S. has built up a domestic nitrogen industry, chiefly for strategic purposes.

The Chinese Peoples Republic, on the other hand, has become a promising market. Sales to China started in 1952, at first under transit deals through the Netherlands, but are now under direct contracts. They amount to about 50,000 tons p.a.

Two more nitrogen plants are expected to begin production and will increase the proportion of synthetic nitrogen to 90% of the total West German production.

**Chemical exports**

West German exports of chemical goods amounted to about 2,770 million marks in the first nine months of 1956, exceeding by 12½% those in the same period in 1955, it was announced by the Association of the West German chemical industry.

From 1954 to 1955, the corresponding rise was 16% and that from 1953 to 1954 32%, the Association said. Chemical exports accounted for 12½% of the total West German exports in the first nine months of 1956, against 13.4% in the same period of the previous year.

The Association attributed this development to the fact that many countries were primarily interested in purchases of investment goods and tried to restrict consumer goods imports.

Exports of heavy industrial chemical

products maintained the leading position among total chemical sales abroad. They amounted to 662 million marks in the period under review.

Exports of plastics, which amounted to about 250 million marks in the first nine months of 1956, took second place. Exports of pharmaceutical products, which amounted to 247 million marks in the first nine months of this year, advanced to the third place.

West German imports of chemical products amounted to 973 million marks, about 10% more than in the corresponding period in the previous year.

### FRANCE

**Fertiliser production**

By 1959 France's State-sponsored Office National Industriel de l'Azote will be producing at a rate of 500 tons/day of ammonia and 100,000 tons of nitrogenous fertiliser p.a., according to the Office's report for 1955 published in Paris.

The report stresses the leading role played by the Office in promoting the development of ancillary industries close to the natural-gas deposits in south-west France. In 1954 the Office collaborated with the chemical concern Air Liquide to start work on a pilot plant to produce heavy water at Lacq. Production at the plant is due to begin in a few months' time.

In September 1956 the Office joined with Pechiney, Saint-Gobain, Pierrefitte and the Banque de Paris et des Pays-Bas to set up the Societe des Produits Chimiques d'Aquitaine—the first unit in a projected chemical industry based on the gas deposits.

In addition, it has set up two research centres specialising in applied chemistry and agronomy.

### PORTUGAL

**Cheaper industrial chemicals**

The Under-Secretary of State for Commerce and Industry recently announced the satisfactory results of efforts to reduce the production cost of certain chemicals which form the raw materials of various industries producing for export. The intention is that the prices of the finished products may also be reduced and become more competitive in markets abroad.

The supply through pipelines of brine made from rock salt and of electricity at special prices will result in the reduction of the prices of several products by sums varying from 140 to 1,500 escudos/ton, which equal from 8 to 30% of the price. The materials in question are sodium carbonate, caustic soda and chlorine, and the glass, soap, wool and paper industries are principally concerned.

**Chemical fertilisers**

The Government has reported a substantial increase in the use of fertilisers and points out that this is due to the policy, in force since 1937, of subsidising the sale of fertilisers. They recognise, however, that further advances need to be made in the use of potassic fertilisers. They are also concerned to encourage the use of lime, in view of the high acidity of a great proportion of the cultivated soil in Portugal (86.8%), and propose therefore to extend the subsidies in future to cover lime for agricultural purposes as well.

**The Leonard Hill Technical Group—January**

*Articles appearing in some of our associate journals this month include:*

**Fibres**—Keeping Fabrics Clean, 2; The Search for and Production of New Fibres, 1; Developments in Textile Machinery—Pirn Winding; International Conference on Textile Labelling, 2.

**Corrosion Technology**—Mercury-Containing Anti-Fouling Paints on Aluminium Alloy Hull Plating; Cathodic Protection for Small Shipping; *Epikote* Resins in Marine Applications; Combating Heavy Fuel Corrosion and Cylinder Wear in Marine Engines; Anti-Corrosion and Anti-Fouling Paints for Ships' Hulls; Corrosion, Its Causes, Cost and Prevention.

**Building Materials**—Protective Paints; Reducing the Cost of Dressed Stone: New Methods, Machines and Techniques.

**Floors**—Wood, Its Properties as a Flooring Material; The Insulation of Composite Concrete Floors.

**Food Manufacture**—Preview o the Packaging Exhibition; Annual Reviews: Brewing, Confectionery, Ice Cream; Malt Vinegar Production; Collaborative Study on the Fibre Content of Catfeed; The Keeping Qualities of Fruit and Vegetable Concentrates: A New Department of Food Science.

**Dairy Engineering**—New Trends in Bottle Washing; Planning the Smaller Dairy; A New Stainless-Steel Butter Churn; Dairy Plant at the 1956 Vochema Exhibition.

**Muck Shifter**—Gas Turbines for Earth Moving Equipment; Machinery Pontoons for Excavating River Beds; Construction of Tunnel with Steel Tubes.

**Petroleum**—British Refinery Review; Producing at Pernis; Styrene from Petroleum; Protecting a Fluid Catalytic Cracking Unit; Computers for the Petroleum Industry; Russian Work on Strata Fracturing; Cleaning Tanks in Oil Tankers; B.P.'s New Engine Testing Laboratory.

**Automation Progress**—Printed Circuits in the Electrical Industry; British Progress in Digital Computer Design; Machines That Think; Trends in American Automation.

**Atomics**—Nuclear Power for Aircraft; Liquid Metals and Nuclear Power; Reactor Technology for the Engineer, 1: Fission Processes; Nuclear Power and Gas Turbines, 2; French Atomic Power Development; The Problem of Liquid and Gaseous Effluent Disposal.

### RHODESIA

**Pyrochlore deposits discovered**

Promising deposits of pyrochlore-bearing carbonates have been located in the Feira district of Northern Rhodesia about 150 miles east of Lusaka. The Northern Rhodesia Director of Geological Survey said that one of the deposits might be the largest ever known in Africa, if not in the world. Pyrochlore contains niobium, a metal in world demand for the manufacture of certain parts of jet engines.

### PANAMA

**Mining operations**

The United States' aluminium firm of Alcoa is seeking a concession in Chiriqui Province and two other U.S. companies, the Utah Construction Co. and the New York, Honduras & Rosario Mining Co., are interested in surveying for minerals in Panama. The discovery of oil in commercial quantities in Costa Rica near the Panamanian frontier, together with the Suez crisis, has aroused an interest in Panama's possible oil sources. The Union Oil Co. has started test drilling in its concession on the Panamanian side of the frontier. The Cataract Mining Corp., of New York, and the International Oil & Metal Corp., of Los Angeles, have also obtained concessions in Panama and a number of other major oil companies are reported to be seeking concessions.

### NIGERIA

**New oil find**

An exploration well near Afam, 20 miles east of Port Harcourt, Nigeria, has encountered oil and gas during the first stages of testing.

### SPAIN

**Zinc factory project**

The Compania Espanola del Cinc have requested authorisation to set up a factory near Santander to produce pure zinc, operating on about 40,000 tons p.a. of concentrated blendes. The cost is estimated at 284.7 million pesetas, of which something less than 100 million will be spent on imported machinery.

## UNITED STATES

### Jefferson Chemical Co. expansion

Jefferson Chemical Co., jointly owned subsidiary of the American Cyanamid Co. and the Texas Co., plans a major expansion of its petrochemicals plant at Port Neches, Texas. Industry sources estimated the cost of the programme at between 35 and 40 million dollars.

Jefferson intends to treble production facilities for ethylene, double capacity for ethylene glycol and raise by 50% the output of ethylene oxide.

### New coating for grain bins and elevators

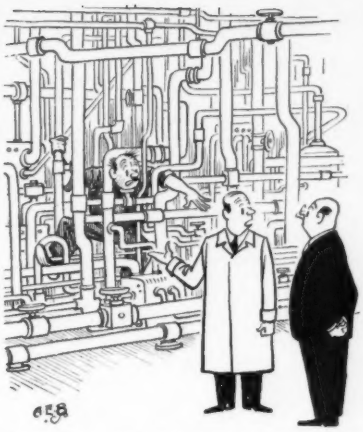
Two companies—the Chemical Division of the Borden Co. and the Steelcote Manufacturing Co.—have produced an exterior coating which can seal any surface against outside moisture but still exhale interior vapour. This is expected to save millions of dollars a year to the grain industry in storage losses.

The new coating was evolved by the Steelcote Co. from a Borden polyco polyvinyl acetate emulsion. Called *Ply-tex* No. 2, the coating is said to have excellent adhesive qualities, is quick drying, tough and highly resistant to heat and salt air corrosion.

### Automotive anti-freeze plant

Plans for the construction of a modern $1½-million plant for the formulation and packaging of automotive anti-freeze at Mapleton, Illinois, on the Illinois River ten miles south of Peoria, have been announced by Olin Mathieson Chemical Corp.

Ultra-modern jet formulating equipment will enable the plant to turn out 12 million gal. p.a. of anti-freeze. This will make it the largest of Olin Mathieson's anti-freeze formulating plants and one of the largest of such operations in the country.



"IT'S FRED—HE'S FIXED IT ALL RIGHT BUT NOW HE CAN'T FIND HIS WAY OUT"

### Butadiene plant contract

The Fluor Corporation Ltd. has been awarded a contract for the construction of a butadiene plant for the Odessa Butadiene Co., Odessa, Texas. The plant will have a capacity of 50,000 tons/year of butadiene. Construction is scheduled to start in midsummer and to be completed a year later.

## GREAT BRITAIN

### Butadiene plant in operation

Head Wrightson Processes Ltd. announce that the butadiene extraction plant engineered by them for Imperial Chemical Industries at its Wilton works, Yorkshire, has been completed and successfully operated at the design rate of several thousand tons p.a. The main outlet for the product is in the range of copolymers marketed by I.C.I. with the trade mark *Butakon*. Head Wrightson Processes carried out the work of engineering design and procurement in close collaboration with the licensors of the process—Phillips Petroleum Co., of Bartlesville, Oklahoma—and with I.C.I. staff who also undertook the work of site erection.

### Work study progress

Progress of work study methods and their successful application formed the basis of a survey given by R. M. Currie, C.B.E., head of the central work study department of I.C.I., to the Edinburgh Productivity Committee. From 1938 wages had doubled, but, despite this and the fact that materials are now costing four times pre-war levels, I.C.I. had advanced their prices by only 93%. They had recently announced that home trade prices would be held steady until June of this year, in which programme work study had a share. He paid a tribute to the far-sighted unions and to the T.U.C. in their efforts to have their own people trained in a proper appreciation of work study techniques and scopes.

### Change of address

The Institution of Chemical Engineers has moved to 16 Belgrave Square, London, S.W.1.

### Natural gas at Cousland

As part of the Gas Council's five-year programme of exploration for supplies of natural gas in Britain, the Scottish Gas Board propose to carry out a prolonged test of the natural-gas resources existing at Cousland, near Edinburgh, to establish whether the supplies of town gas to consumers could be augmented from this source on a commercial basis.

Natural gas has a calorific value of more than double that of coal gas normally produced in continuous vertical retorts. If the test to be under-

## *COMPANY NEWS*

Joseph Crosfield & Sons Ltd. have announced a major factory rebuilding programme which will take about eight years to complete and will cost at least £5 million. During the rebuilding, production will not be interrupted. Completely new laboratories, with pilot-plant facilities, are included in the plans.

It is hoped that building operations will start this year.

*

The Du Pont Co. (United Kingdom) Ltd. announced recently that it has taken options on a 381-acre tract near Londonderry, Northern Ireland, as the prospective site for a neoprene synthetic rubber plant.

The site is located four miles north-east of Londonderry and 55 miles north-west of Belfast. Two waterways adjoin the property, the River Foyle on the north and the River Faughan on the east.

The company stated that start of plant construction in early 1957 was contemplated, assuming successful completion of engineering and economic studies now under way.

*

Under the chairmanship of Mr. J. O. Hitchcock, sales director of the Mond Nickel Co. Ltd., a conference held by the company at Geneva recently was devoted to matters relating to availability of nickel in relation to industry's expanding requirements in all countries, and to questions concerning production and distribution of primary nickel products.

*

The British Oxygen Co. Ltd. and George Wimpey Ltd. have formed a jointly owned subsidiary to be known as British Oxygen Wimpey Ltd. The purpose of the new company is the construction of special rocket projects.

taken at Cousland leads to commercial production it is possible that the utilisation of the natural gas from that source would result in a saving of some 5 to 10 thousand tons of coal p.a.

### FINLAND

**Seeking new ores**

Several interesting discoveries have been made as a result of competitions arranged by the Finnish Government for the discovery of new source of mineral ore. It is too early to say whether any of these will lead to full-scale mining as no drillings have yet been made, but several deposits of uranium have been discovered in south-west and south Finland.

### SOUTH AFRICA

**Oil blending plant**

At Island View, Durban, Caltex (Africa) Ltd. have what is claimed to be the first fully automatic oil-blending plant of its type in southern Africa. This plant has been erected on a four-acre site and is designed for the production of a full range of lubricating oils from the base stocks imported from the United States. Included in the equipment of the plant is a Cornell oil compounding and blending homogeniser, with an electrically operated fully automatic proportioning panel designed for pre-setting to control the flow of various types of oils to blend into any required type, the necessary additives being combined with the oil at the same time. Any interruption in the flow switches off the panel.

The base stocks used in this plant are laboratory tested for quality before being put through any of the processes, and later there is a further laboratory check to ensure that the blend is in the correct proportions. So far as possible South Africans are responsible for all the processes concerned, some of them having gone to the United States to receive special training in these processes.

**Magnetic separator**

Allenwest S.A. (Pty.) Ltd., Johannesburg, are making a magnetic separator originally designed for the extraction of iron from gold-bearing slimes during or after the reduction process, but, as it can be applied to any material which can be made to pass through a launder or chute of suitable shape, it is also used in the uranium mines. The material must be of such a nature that the spikes can pass through it freely. All the magnetic material is thus readily extracted.

# INDUSTRY REPORTS . . .

### *U.S. plastics projects*

Celanese Corp. of America reported increases in both sales and earnings for the first nine months of 1956 over those of the same period last year.

In the report, the president, Mr. H. Blancke, noted that construction has started at the Celanese Bishop, Texas, chemical plant of a new polyol production unit, which will supply intermediates for the rapidly growing polyurethane plastics and coatings fields. The unit, scheduled to begin operation late in 1957, also will produce chemical components for alkyd resins, high-quality brake fluids and other industrial materials.

Progress is also being made with the construction of the new Celanese low-pressure polyethylene plant at Houston, Texas. One unit is now in production and the main plant should be in operation early this year.

### *Superphosphate plant for South Africa*

The Albatros Superphosphate works of Utrecht, together with their British partner, are planning to establish a South African superphosphates factory, according to the company's report for 1955-56.

The report said that the company's subsidiaries in South Africa and Rhodesia had obtained very satisfactory results and that it was possible to raise exports to these territories.

Albatros's three main products are superphosphates, double superphosphates and mixed fertilisers.

Albatros is carrying out an extensive programme of renewal and extension, particularly at Pernis, near Rotterdam, where modernisation of the port facilities is in full swing. The company's investments since the end of the war have now reached nearly 36 million guilders, while depreciation is estimated at 23.4 million.

### *Educational assistance programme*

In a letter to the shareholders accompanying the interim report of the International Nickel Co. of Canada Ltd. for the nine months ended September 30, 1956, the chairman, Dr. J. F. Thompson, reviewed the company's recently expanded programme for aid to higher education in Canada. Under the new programme, grants totalling $2½ million will be paid over a five-year period. Half of the 40 scholarships to be awarded are limited to study in geology, geophysics, mining, metallurgy and engineering in order to encourage students to choose careers in these fields.

It was pointed out that it would be to the mutual advantage of the country and of industry to have a source of adequately trained technical personnel to draw upon.

### *Expansion of industrial activity*

Announcing, in a report to the stockholders, the sale of its Bradley Container Division, manufacturers of plastic tubes and bottles, to American Can Co., and of its Lentheric Division to Helene Curtis Industries Inc., the Olin Mathieson Chemical Corp. points out that these transactions are consistent with the policy of concentrating its energies and resources in its major fields of industrial activity.

Also consistent with this policy is the programme of aluminium expansion which has previously been noted in this journal. The new affiliate company, Olin Revere Metals Corp., which is the result of this programme, will own the alumina plant to be built on the Gulf Coast, the enlarged reduction plant now under construction near Clarington, Ohio, and the major portion of the electric power facilities.

### *Constructive oil policy*

To judge from the chairman's review in the annual report of South African Torbanite Mining & Refining Co. Ltd., the declining amount of torbanite available for treatment has been successfully made up by the processing of imported crude oil. During the past year the company has been able to co-operate with the Sasol oil-from-coal undertaking in absorbing for processing initial quantities of residual oil from their plant. The question of replacing some of the refining plant with up-to-date equipment more suited to the processing of imported crude oil and the production of the ever-increasing quantities of refined products which the market requires is at present under investigation. The chairman adds that the improvement of the trading profit from £72,578 to £103,538 is gratifying. It is due, to a large extent, to a reduction in the cost of torbanite oil production and also to the increased refinery throughput. These remarks show that the company is trying to adopt a constructive policy which should enable it to continue along with other refinery undertakings in the Union even after the torbanite deposits of economic value have been exhausted.

# ★ Personal Paragraphs ★

★ The Council of the Association of British Chemical Manufacturers has appointed **Mr. G. Brearley,** B.SC., F.R.I.C., M.I.CHEM.E., as the director of the Association in succession to **Mr. J. D. Pratt,** who is retiring in June this year. Since April 1953, Mr. Brearley has been a partner of Cremer & Brearley, consulting chemical engineers. From 1926 to 1953 he was employed by Brotherton & Co. Ltd. and was a director of that company from 1938 and managing director from 1946 until his resignation in 1953. His A.B.C.M. activities have included membership of Group D and participation in chemical works safety conferences. He has also been active in A.C. and A.E. affairs and was, in 1952, chairman of the Chemical Group. He has been a member of the Councils of the Royal Institute of Chemistry and the Institution of Chemical Engineers, and is chairman of the Annual Reports and Monographs Sub-Committee of the Society of Chemical Industry.

★ The Power-Gas Corporation Ltd., Stockton-on-Tees, has announced the appointment of two divisional directors who will be responsible for the development of the company's trade within special fields. **Mr. P. M. K. Embling** was appointed manager of the chemical plant division in 1955 and he now becomes divisional director responsible for that division. **Mr. D. R. Brown** was appointed manager of the blast furnace division of Ashmore, Benson, Pease & Co. in 1955 and as divisional director he is now responsible for the promotion and development of blast furnace and ancillary plant marketed by the company.

**Mr. P. M. K. Embling.**

★ The directors of the newly formed company, British Oxygen Wimpey Ltd., are **Sir G. W. Mitchell,** chairman, who is also chairman of George Wimpey Ltd., **Mr. F. J. Clark,** managing director of British Oxygen Ltd., **Mr. R. U. Law,** managing director of George Wimpey Ltd., **Dr. L. G. Groves** and **Mr. G. M. Harvey** of British Oxygen and **Mr. D. R. W. Watts** of George Wimpey Ltd.

★ **Mr. P. G. Astles** has joined the board of Union Oxide & Chemical Co. Ltd., London. He has been engaged on the technical developments of the company since 1954.

★ **Mr. L. W. Stevens-Wilson** has been appointed development officer to the British Iron and Steel Research Association in succession to **Dr. T. E. Dancy,** who resigned recently to take up an appointment in the United States. Mr. Stevens-Wilson has had a wide experience of the commercial exploitation of new industrial developments, especially in the fields of heavy engineering and chemical processing.

★ At the annual general meeting of the British Tar Confederation held on November 26, 1956, the following were elected as officers of the confederation for the year 1956-57: **Sir Harold Smith,** K.B.E., D.L., president; **Mr. L. W. Blundell,** honorary treasurer; **Mr. R. H. E. Thomas,** O.B.E., chairman of the executive board; and **Sir Henry F. H. Jones,** M.B.E., M.A., and **Mr. S. Robinson,** vice-chairmen of the executive board

★ Metropolitan-Vickers Electrical Co. Ltd. has announced that **Mr. H. H. Lusty** is appointed manager of the publicity department. He succeeds **Mr. E. E. Walker,** who is retiring but will act in an advisory capacity until the end of January.

★ The appointment of **Mr. G. Sims-Davies** as equipment manager of British Oxygen Gases Ltd. has been announced. He joined British Oxygen in 1938 as an assistant engineer, and became chief engineer for British Industrial Gases Ltd. in 1940. He returned to the British Oxygen Co. in 1950 as assistant district engineer for the Midlands division, and was appointed to the post of district engineer in the same year. He became district engineer for the firm's Lancashire division in 1953.

★ **Mr. R. J. C. Bryce** has been appointed district manager of the Scottish Division of British Oxygen Gases Ltd. He was appointed managing director of British Industrial Gases Ltd. in 1953.

★ **Mr. A. Brown,** formerly area manager of the Birmingham office of Dewrance & Co. Ltd., is appointed chief assistant to **Mr. B. S. Bass,** sales manager, and is now at their London office. **Mr. D. G. Seymour,** formerly area manager of their Cardiff office, is taking over the Birmingham area as manager. **Mr. J. Best** is appointed manager of the Cardiff area.

## A Publisher Goes Abroad

*Mr. W. Leonard Hill, founder and chairman of the Leonard Hill Technical Group, photographed with his daughter, Miss Lynette Hill, just before his departure on his world tour. He will be conferring with the company's agents, contributors and consultants in Australia and the United States.*

*Mr. Hill will be in Sydney until January 25 and may be addressed c/o Sir Norman Nock, Box 4250, G.P.O., Sydney. He will be arriving in Los Angeles on February 19 and may be addressed c/o Mr. Robert M. Hixson, Hixson & Jorgensen Inc., 3257 Wilshire Boulevard, Los Angeles 5. Finally, he will spend a period in New York and, from March 31, may be addressed at the Yale Club, 50 Vanderbilt Avenue, New York 17. He departs for England on April 17.*

# British Patent Claims

### Liquid-operated servo-mechanism

In a mechanism, *e.g.* for fuel control for a gas turbine, a lever is operated by components responsive to two fluid pressures, one component comprising an axially deformable elastic capsule between the lever and a servo-mechanism. The force exerted on the lever by the capsule is variable in response to servo-mechanism movement.—758,523, *Lucas (Industries) Ltd.*

### Tube joint

A ferritic tube and an austenitic tube (*e.g.* in a heat exchanger) are butt welded together and the end parts are surrounded by a prestressed compressive ring of ferritic material, one end of such ring being welded to one tube, the other being in flange engagement with the other.—758,616, *Babcock & Wilcox Ltd.*

### Flue gas heat exchanger

Outwardly radiating ribs on a tubular body (and the body) are surrounded by a jacket, and the flue gas passing through the tubular body heats air in the annular passage between the body and the jacket. A twist motion is given to the air by the ribs and by vanes.—758,586, *Industrie-Companie Kleinewefers Konstruktions-und Handelsges (Germany).*

### Vacuum filter

An apertured corrugated member(s) is carried by members which provide drain channels, and supports a filter cloth, etc. Vacuum is applied to such corrugated member for filtration, and gas under pressure is applied to dislodge filter cake from the cloth.—758,325, *Eimco Corp. (U.S.).*

### Carbon for filtration and separation

Inorganic matter is removed from peat or peat moss, which is then wetted to allow subsequent disintegration without loss of fibre structure. The disintegrated peat is then carbonised and retains such structure.—758,387, *Metafiltration Co. Ltd., et al.*

### Rotary suction drum filter

A drum rotates in a vat containing liquid (or pulp) to be filtered, operates with inward flow and has outlet ducts. A suction box at the lower end of the drum is openable to the outlet ducts during a minor part of each drum revolution.—758,486, *Black-Clawson Co. (U.S.).*

### Plasticised compositions

Polymers or copolymers of tetrafluoroethylene and trifluorochloroethylene are combined with 0.5 to 30% wt. of an oleaginous halohydrocarbon(s) (distilling at 230 to 360°C. at 760 mm. Hg and containing 14 to 44% F and 30 to 61% Cl) by heating at 100 to 360°C. The product is used as a lubricant which is resistant to attack by corrosive chemicals (*e.g.* as a valve packing material).—758,362, *Imperial Chemical Industries Ltd.*

### Dust extractor

Suspended dust filter sleeves (*e.g.* of an air filter) are displaced bodily in such manner that they gyrate in a plane normal to their axes during cleaning.—758,207, *G. Fischer (Germany).*

### Polymerisation process

A high-solids-content polymer emulsion is produced by polymerising an ethylenic monomer in aqueous alkaline emulsion, in the presence of a polybasic polymer of an unsaturated $<C_{10}$ carboxylic acid as emulsifier. The weight of monomer is $<$ the weight of aqueous phase and polymerisation is continued until the total solids content is $<40\%$. The lattices are used in the protection of paints or are blended with other lattices to give deposited articles, *e.g.* gloves.—758,150, *International Latex Corp. (U.S.).*

### Heat and soluble substance exchanger

The heavier of two flowing media of differing specific weights is centrifuged over rotating surfaces and the lighter medium is counter-flowed over the heavier medium. The rotating surfaces are subdivided to form numerous channels which control the flow in specified manner.—757,149, *C. W. Pilo (Sweden).*

*The above are abstracts reproduced from the weekly* Patents Abstracts Journal *by permission of the Technical Information Co. The complete specifications can be obtained from the Patent Office, 25 Southampton Buildings, London, W.C.2, price 3s. each.*

# MEETINGS

#### Institution of Chemical Engineers

*January* 16. 'Equilibrium Flash Vaporisation of Coal Tar and Coal-tar Fractions,' by D. K. H. Briggs and F. Popper, 7 p.m., The University, Leeds.

*February* 2. 'Automatic Control of Continuous Distillation Plant,' by E. J. Eaton and R. Parkins, 3 p.m., The Midlands Institute, Paradise Street, Birmingham.

*February* 5. 'Liquid-liquid Extraction,' by H. R. C. Pratt, 5.30 p.m., The Geological Society, Burlington House, London, W.1.

#### Chemical Society

*January* 16. 'Studies of Knock and Anti-knock by Kinetic Spectroscopy,' by Prof. R. G. W. Norrish, 6.30 p.m., Chemistry Lecture Theatre, Manchester University. Joint meeting with the Royal Institute of Chemistry and the Society of Chemical Industry.

*January* 21. 'Radiation—Chemical Reactions in Aqueous and Non-aqueous Solutions,' by Dr. E. Collinson, 8.30 p.m., University Chemical Laboratory, Lensfield Road, Cambridge.

#### Incorporated Plant Engineers

*January* 16. 'Steam Raising by Oil Fuel,' by H. W. Hastings, 7 p.m., King's Head Hotel, High Street, Rochester, Kent.

#### Institute of Metals

*January* 30. 'The Preparation of Germanium and Silicon for Use in Semiconductor Devices,' by S. E. Bradshaw, 6.30 p.m., Manchester Room, Central Library, Manchester.

*February* 7. 'Fuel Ash Corrosion Problems,' by Prof. A. Preece, 7.15 p.m., Large Chemistry Lecture Theatre, The University, Leeds 2.

#### Society of Instrument Technology

*January* 23. 'Pressure and Pressure Difference Measurement,' by E. N. Martin, 7.30 p.m., Cleveland Scientific and Technical Institution, Corporation Road, Middlesbrough.

#### Fertiliser Society

*January* 31. 'The Use of Different Types of Phosphate Rock in Single and Triple Superphosphate Production,' by T. P. Dee, R. J. Nunn and K. Sharples, 2.30 p.m., Lecture Hall of the Geological Society, Burlington House, Piccadilly, London, W.1.

#### Junior Institution of Engineers

*January* 11. 'Metal Bonding,' by R. A. Johnson, 7 p.m., Pepys House, 14 Rochester Row, Westminster, London, S.W.1.